

博士論文

**Holocene Vegetation and Human Activities in
Northern Vietnam**

(北ベトナムにおける完新世の植生と人間活動)

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グエン・ティ・マイ・フォン

NGUYEN THI MAI HUONG

Department of Socio-Cultural Environmental Studies

Graduate School of Frontier Sciences

THE UNIVERSITY OF TOKYO

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ABSTRACT

Northern Vietnam, the birthplace of Vietnamese history, is located near the intersection of the tropical and subtropical zones, and is subject to the biotic influence of three biogeographic regions: Indochina, South China and East Sea. In the Holocene, the geography and ecosystem of the area were mainly shaped by riverine activities and sea level changes. These phenomena have strongly impacted both natural environments and human activities in Northern Vietnam.

Pollen analysis is a powerful tool in our attempts to better understand the inter-relationships of natural vegetation, environmental history and human agricultural activities. Pollen analysis at archaeological sites is based on a prior understanding of natural pollen bio-stratigraphy in the area. With this foundation we can gain a clearer picture of changes in the cultural and natural landscapes of Northern Vietnam during the Holocene.

In the early Holocene, sea level was lower than today with important effects on coastal areas, rivers and their adjacent flood plains. This is the time period of the early Neolithic marked by the important Hoa Binh culture which is well known, not only in Vietnam, but throughout Southeast Asia for its distinctive diversity of agriculturally related and other lithic tools. The cultural achievements of the Hoabinhian and post-Hoa Binh cultures provided the prerequisites for the formation and elaboration of subsequent Neolithic cultures of Northern Vietnam. In the early Neolithic period, most archaeological sites were distributed over a wide range of higher altitude 'montane' terrains at 25 or more metres above sea level. By contrast, in the late Neolithic period, archaeological sites were primarily located in the plain and coastal areas.

Pollen analysis shows that the natural vegetation of Neolithic period was composed mainly of land plants, with very few brackish and mangrove plants. Tropical plants were composed of *Magnolia*, *Morus*, *Sapindus* and Rubiaceae; sub-tropical plants consisted of *Castanopsis*, *Liquidambar*, and *Hamamelis*; temperate plants included *Pinus*, *Quercus*, *Castanea*, *Juglans*, *Ulmus*, *Ilex* and herbs such as Compositae, Chenopodiaceae, Malvaceae, Leguminosae, Cyperaceae and Poaceae. In the archaeological cave sites, fern spores occurred in higher percentage than other plant groups indicating a humid climatic condition. At the sites located in the plain, pollen of arboreal and non-arboreal taxa dominated.

Pollen grains of such plants as Poaceae, Malvaceae, Palmae, and *Morus*, recorded at these archaeological sites, may relate to the plants that began to be cultivated in Southeast Asia. In addition to pollen, macro-plant remains include *Gnetum montanum*, *Linstora cochinchinensis*, *Elaeocarpus sylvestris*, *Phyllanthus emblica*, *Thea*, *Canarium*, *Cucumis*, *Lagenaria*, *Areca*, *Livistona*, and *Prunus*. Some of these are still exploited by Muong people in Northern Vietnam.

The Early–Middle Holocene is characterized by the strongest marine transgression (viz. Flandrian) with the entire study area being strongly influenced by activities of the sea. Sea level rose 2–3 m during the Holocene, sea level highstand about 6,000–4,000 cal. yr BP. In the lower strata of the coast and marsh, markers of a deltaic environment prevail. However, the upper part is characterized by the delta front and delta plain wetlands. Combined with the presence of pollen, the climate of this area can be defined as subtropical, humid tropical. During this time, mangroves show rapid growth in their number and taxonomic composition, represented by *Avicennia*, *Rhizophora*, and *Bruguiera*. Brackish water vegetation is plentiful as indicated by sediment cores from Dong Son.

In the Middle-Late Holocene, sea level declined over the period from 4,000 cal. yr BP to the present, creating changes very close to the present coastline. Based on changed geographical conditions, ancient peoples had moved down from higher areas to reside in the Red River Delta and northern central coastal plain, creating plentiful Pre-Dong Son and Dong Son archaeological sites in lowland, coastal and plains areas. The introduction of metal at this time brought great changes to the lives of the ancient inhabitants in Northern Vietnam in general and the river basins in particular. Archaeologists have found a diverse set of tools made from both stone and metal, with specialized farming functions such as the plow, hoes, reapers, sickle, tweezers, knives, etc. Wood working tools were used to cut trees to make boats and other wooden objects.

Pollen analysis of Pre-Dong Son (Bronze Age) archaeological sites indicates that the flora of Northern Vietnam at that time was a combination of tropical herbs, shrubs and primary forest plants, not much different from the Neolithic period, which prefer a hot and humid climate. In a number of archaeological sites, spores dominate especially at lower strata; a phenomenon indicating wet conditions for the area. Mangroves significantly reduced. Marshes and tidal habitats prevail. The amount of herb pollen such as Poaceae, Compositae, etc increased while pollen grains of arboreal plant like Magnoliaceae and *Pinus* reduce which may indicate human influence. Pollen grains of Poaceae occur in high percentage which may be related to nearby paddy cultivation and agricultural activities. In addition, archaeologists have found a lot of burnt rice grains from Phung Nguyen

culture layers at Dong Dau and Thanh Den sites, providing the most convincing evidence for agricultural activity and the relationship between human activities and vegetation.

In the Metal Age, as agriculture and domestication of animals took precedence over hunting and gathering, people became increasingly sedentary and the conduct of daily life began to have broader impacts on the local environment. To meet agricultural needs, people may have started to fell trees and clear expanses of land since pollen diagrams show reduced number of arboreal pollen. Archaeologists have been found many artifacts relating to the continued development of rice cultivation, including bronze plowshares, sickle blades, and depictions of people planting or pounding rice. Bamboo, cyperus and rattan imprint on pottery, gourd ladles, and evidence for numerous styles of fabric have also been recovered in some waterlogged sites in Ha Tay and Hai Phong province. The diversification and intensification of agriculture substantially altered the landscape. At the same time, the making of pottery flourished, with very beautiful and harmonious styles as can be seen among the Phung Nguyen, Dong Dau and Go Mun cultures. Techniques for making pottery also improved as shown by diverse typology, sherd numbers and kiln temperature. Charcoal particles included in the pottery fabric relate to vegetation disturbance. Decorations on the Dong Son bronze drums illuminate perceptions and uses of the environment during this time. Illustrations depict the sun, herds of deer, buffalo, aquatic birds, and men robed in garments decorated with feathers of aquatic birds, showing that people existed harmoniously with the environment.

At the Dong Son site, we have found mangrove species at a depth of about 1 to 6m. They are mainly *Rhizophora* and *Bruguiera*, dated around $4,810 \pm 45$ yr BP to $7,043 \pm 56$ yr BP. These indicate that sea level changes had affected this area resulting in shallow tides for long intervals. In the upper part (about 1-2m depth, date about 3,000-2,000 yr BP.), fern spores included *Lygodium*, *Polypodium*, *Cyathea*; Polypodiaceae, *Stenochlaena*, and *Microlepia*. Tree pollen types are mainly a mixture of indigenous lowland monsoon forest species such as *Castanea*, *Castanopsis*, *Lithocarpus*, *Magnolia*, *Michelia*, *Quercus*, *Palmae*, *Myrtus* and with some pine (*Pinus*). The amount of pine pollen is so low, it is unlikely that pine was growing anywhere near the site. In all pollen diagrams, non-arboreal pollen dominated. Pollen grains of Poaceae increased whereas the gradual reduction of arboreal pollen may due to human land clearance. Poaceae pollen in all diagrams includes both large (above 30 to 40 μ m in diameter) and small grains which may indicate the presence of *Oryza sativa*. Moreover we found traces of rice imprinted in Dong Son's pottery, demonstrating that agricultural activities occurred around the Dong Son site at that time.

Based on this research, it is argued that vegetation patterns during the Holocene in Northern Vietnam reflect both natural and cultural influences on the environment. Vegetation was likely a mosaic of grassland species, shrub trees and native forest. Combined pollen analysis and archaeological evidence, show the impact of early agricultural activities of prehistoric populations on natural vegetation data presented here provide a clearer picture of changing vegetation, environment, and human-environment interactions throughout the Holocene in Northern Vietnam.

The collection and interim synthesis of pollen data presented in this study, especially at the site of Dong Son, highlight areas of progress in our emerging knowledge of human-environment interactions during the Holocene in Northern Vietnam. These results highlight areas for future research by pollen analysts in order to enhance the tracing of agricultural origins in Northern Vietnam.

論文の内容の要旨

この研究は北ベトナムにおける完新世の植生変遷および植生と人間活動のかかわりの歴史を明らかにしようとするものである。北ベトナムは熱帯から亜熱帯への移行帯に位置しており、インドー中国区、南中国区、東海区の三つの生物地理区にまたがっている。完新世におけるこの地域の地形・地質と生態系は、河川の活動と海水準変動の影響を強く受けてきた。このような変動はまた自然環境と人間活動にも強くかかわってきた。このような地域において、植生変遷ならびに植生と人間活動とのかかわりの歴史を解明するのに花粉分析は有効な手法である。考古学的な遺跡における花粉分析的研究は、新たな花粉生層序を設定し、他の地域で知られる花粉生層序との対比を可能にする。さらに考古学的な知見を総合することによって北ベトナムにおける完新世の遺跡と周辺域の景観生態系を描き出すことができる。

第2章では、北ベトナムにおける完新世の自然環境の変遷、ならびに考古学による社会文化史を総説した。とくに後半の社会文化史では、古いほうから新石器文化、先ドン・ソン文化、ドン・ソン文化に分けて詳述した。自身の遺跡発掘による知見や北ベトナム各地の博物館に保管される遺物調査による知見が多数盛り込まれている。

第3章では研究の方法を記述した。まず、考古学による調査が行われた北ベトナムの17の遺跡を調査・研究対象にしたことを述べた。本研究では、地質学的手法であるボーリング調査、植物・生態学・古生物学的手法である花粉分析、年代・編年学的手法である放射性炭素年代測定を主として用いており、考古学では環境考古学の手法を駆使している。花粉分析では、温帯域での湿原堆積物や後背湿地堆積物といった花粉含有量が多く保存性の高い堆積物ではなく、花粉の含有量が著しく少ない河成の氾濫堆積物やデルタ堆積物を対象とするため、新たな分析方法を開発した。

第4章は本研究の主要部をなす花粉分析の手法を用いた分析結果の記載である。まず第1節では、北ベトナムでのこれまでの乏しい研究史をまとめた上で、新石器文化の遺跡、先ドン・ソン文化の遺跡、ドン・ソン文化の遺跡に分けて記載し、続く第2節では北ベトナムでは初めての遺跡での本格的なボーリング調査とコアの分析を実施したドン・ソン遺跡（ドン・ソン文化の模式地）を記載した。以下では古いほうから花粉分析の結果と考古学の資料を総合した植生と環境、人間活動のかかわりを記述した。

完新世の前期では、海水準が今日よりはるかに低かったため、現在の北ベトナム地域は海の影響をほとんど受けず、河川の活動の影響を強く受けていた。この時期は、ホア・ビン文化から始まる新石器文化の時期にあたる。ホア・ビン文化は石器の明瞭な多様化によってベトナムだけでなく広く東南アジアにおいてよく知られている。新石器文化前期の遺跡のほとんどは標高約25mかそれより高い台地から山地にかけて広く分布している。一方新石器時代後期の考古学的遺跡は北ベトナムの平野から沿岸域に分布する。ホア・ビン文化とホア・ビン文化に続く諸文化の成立は、その後の新石器文化の形成と発展の好適な必須条件となった。

この時期の自然の植生は陸域の植物群によって構成され、汽水やマングローブの植物群はまれであった。花粉として同定された陸域の植物群には、モクレン属、クワ属、ムクロジ属、アカネ科といった熱帯植物、シイノキ属、フウ属、マンサク属といった亜熱帯植物、マツ属、コナラ属、クリ属、クルミ属、ニレ属、モチノキ属のほか、キク科、アカザ科、アオイ科、マメ科、カヤツリグサ科、イネ科といった草本類を含む温帯植物が含まれる。洞窟遺跡では、湿潤な状態を示すシダ類の胞子が高率で検出される。一方、平野に位置する遺跡では、樹木と草本花粉が優占する。イネ科、アオイ科、ヤシ属、クワ属の花粉は東南アジアでの栽培農耕を示す植物群を含む可能性がある。コン・ムーンク洞窟（タン・ホア地区）、ホム・トラ洞窟とチョ洞窟（ホア・ビン地区）では大型植物遺体群（種子・果実）も検出されており、食用植物であるグネツム属の1種、リンストラ属の1種、ホルトノキ、コミカンソウ属のアンマロク、チャノキ属、カンラン属、キウリ属、ユウガオ属、ビンロウ属、ビロウ属、サクラ属が同定される。ベトナム北部のムオン族はこれらを現在も食用としている。

完新世の前期から中期にかけては規模の大きな完新世海進によって特徴付けられ、調査域の全域が海の影響下にあった。6,000~4,000 cal.BP での海水準は標高 2~3m に達していた。この時期では、ヒルギダマシ属、ヤエヤマヒルギ属、アカバナヒルギ属などの汽水植物群からなるマングローブが急速に拡大した。これはドン・ソン遺跡一帯でのボーリング・コアで確認された。マングローブ湿地や海岸が形成される前期ではデルタであったが、後期になるとデルタフロントと湿地によって特徴付けられた。花粉組成と併せ考えると当時の気候は湿潤熱帯から亜熱帯であったといえる。

完新世の中期から後期では海水準は現在の海水準まで低下し、4,000 cal.BP 以降は海岸線の後退によって特徴付けられる。地理的環境の変化に対応して人間の居住地は高所から紅河デルタや北部中央海岸平野へと移動した。先ドン・ソンおよびドン・ソン遺跡群は低地、海岸、平野に分布する。金属の存在は一般に北ベトナムの居住者の生活を大きく変えることになり、とくに谷底平野では顕著であった。考古学者はほとんどが石と金属で作られた道具類の多様化を見出している。それらには農耕具のような特殊な機能をもった道具類が含まれているからである。

先ドン・ソン期（青銅器時代）の遺跡群における花粉分析の結果は、北ベトナムに分布する草本類、灌木類、天然林の植物群が混在していたことを示している。それは新石器時代に見られた熱帯湿潤気候に適した植物群と大きく違わないものである。多くの考古学的遺跡では、とくに下部の堆積物においてシダ類胞子が優占する。この組成は湿地的環境であったことを示している。マングローブ植物群が減少することは注目すべきことで、マングローブ湿地や海域が広がったことを示している。イネ科やキク科などの草本花粉の増加に対して、モクレン科やマツ属などの樹木花粉の減少は、人間活動の影響を示すかもしれない。多くの堆積物で高率で検出される粒径の大きいイネ科花粉は水田稲作農耕活動を示す可能性がある。考古学者はさらに、ドン・ダウおよびタン・デン遺跡のブン・グエン文化層から多量の炭化米を発見している。それらは農耕活動および人間と植生のかかわりを示すゆるぎない証拠である。

金属時代では農耕や動物の家畜化のような狩猟や採集活動に替わる活動が認められ、人間は日常生活に有用性と豊かさを求めるようになり、地域の環境を大きく変え始めた。農

耕活動の始まりは、農耕地のために森林を切り開き、開けた土地を拡大させることになった。花粉ダイアグラムに見られる樹木花粉の減少はこのことを示している。遺跡からはイネ栽培の継続的發展を裏付ける多くの道具類が出土している。それには銅鋤、鎌のほか、人々が米を植えたり、あるいは米をついたりしている図像が含まれる。ハ・タイ地区やハイ・フォン地区における水辺遺跡では、タケやカヤツリグサ、トウなどにより施文された土器や、ヒョウタンの椀、数多くの織り柄があったという痕跡もまた発見されている。このような農業の多様化と強化は景観を大きく変えることになった。

ブン・グエン文化やドン・ダウ文化、それにゴ・ムン文化において見られる美しく均整のとれたモチーフを持つ土器文化が花開いた。土器を製作する技術もまた改善された。それは形式の多様化や、量、焼成温度が示している。初期の微粒炭の産出は植生の攪乱を示している。ドン・ソン文化での銅鼓の装飾からもまた当時の人々の環境に対する認知や利用を復元できる可能性がある。太陽、鹿や水牛の群れ、水鳥や水鳥の羽で飾られた衣服を着た人々が描かれた図像は、人々と環境とが調和して共存していたことを表している。

ドン・ソン遺跡では、ボーリング・コアの地下 1~6m の堆積物からヤエヤマヒルギ属やアカバナヒルギ属といったマングローブ植物群が検出された。その放射性炭素年代は $4,810 \pm 45$ BP、 $7,043 \pm 56$ BP と測定された。このことは当時海水準がこの地域に達するとともに、長期間にわたって海の環境が継続したことを示している。地下 1~2m の $3,000 \sim 2,000$ BP と見積もられる上部の堆積物からはカニクサ属、エゾデンダ属、ヘゴ属、ウラボシ科、フモトシダ属といったシダ類孢子が産出した。樹木花粉は低地のモンスーン林を形成するクリ属、シイノキ属、クリガシ属、モクレン属、タブノキ属、コナラ属、ヤシ属、ギンバイカ属、マツ属などの要素が混在する。マツ属は森林の開発を示す重要な要素と考えられているが、花粉は量的には少なく、周辺域に生育していたとは考えられない。草本類花粉は全体に優占しており、とくに樹木花粉の減少に対してイネ科花粉が著しく増加しているのは人間による開発による可能性がある。いずれの層準からも検出されるイネ科花粉は、粒径が $30 \sim 40 \mu\text{m}$ と大きいものと粒径が小さいものとがともに優占するが、前者は栽培植物であるイネの花粉と考えられる。さらにドン・ソン遺跡から出土した土器からは米の圧痕を発見している。当時、ドン・ソン遺跡の周辺で農耕が行なわれていたかどうかは、もう少し十分な証拠が必要であろう。

この研究によって、北ベトナムにおける完新世の植生の歴史の大筋を描き出すことができた。それは自然の環境変動と人間活動が作り出したものであった。この研究で得られた資料は北ベトナムにおける完新世を通じての植生と環境の歴史、および人間活動とそれがもたらした環境改変の歴史を描き出すための研究の出発点となるであろう。

CHAPTER 1

INTRODUCTION

Northern Vietnam is located in the transition zone between tropical ecosystem and subtropical ecosystem. Diffusions of numerous indigenous biotic communities could be classified into three biogeographic divisions, such as Indo-China, South China and East Sea. The northeastern part borders on GuangXi Province of China, and northwestern and western parts border on Yunnan Laos (Fig.1) (Eleanor J.S et al. 2006; Nguyen Trong Dieu 1995; Le Ba Thao 1997).



Fig.1. Northern Vietnam and its present political borders

Northern Vietnam is considered the original land of Vietnamese history. Archaeological evidence also demonstrates that the earliest settlement of prehistoric people in Vietnam is recorded in Bac Bo plain, Northern Vietnam thousand years ago, that is known as a birthplace of "Red River civilization" (Le Ba Thao 1997; Elenanor S.J. et al. 2006:24). Since the late Pleistocene, numerous cultural and technological developments have taken place continuously onwards. The first is commonly referred to as Son Vi Culture. In general, this culture existed around 30,000-12,000 BP, and habitants of Northern Vietnam during Son Vi period were hunter-gatherers whose tool kits were composed of pebble tools primarily. The majority of known archaeological sites is located on the open slope of hilly terrain or limestone karst mountains.

The Neolithic culture of Northern Vietnam directly followed the Hoabinhian culture with the distinctive lithic, has been well known as a wide diffusion culture spread throughout Southeast Asia as well as Vietnam. The appearance and development of stone hoes and other types of polished axes are most likely related to the onset of the deforestation for the initial cultivation. In addition, the rich corpus of pottery likely reflects post-harvest storage activities then (Bui Vinh 1991; Ha ed. 1998; Bowdler 2008). From approximately 6000-5000 BP, the Hoabinhian Culture has been fragmented gradually into smaller cultural spheres distributed over very restricted areas, such as Da But, Hoa Loc and Ha Long cultures. These distinct material cultural assemblages were scattered over neighboring areas, low density across the plain and coastal areas from the Northeast to the North-central of Vietnam (Ha ed. 1998).

Geological and geomorphological features of the Holocene Northern Vietnam are strongly affected by geological upheaval, especially sea level change. The most of ancient settlement patterns in Vietnam was established under this natural influence, especially in Northern Vietnam. When the regression created favorable settlement conditions, the Neolithic people have abandoned closed rock shelters of mountainous areas gradually, and gain ground along the river course to live willingly. Archaeologists have discovered numerous affiliated sites of Pre-Dong Son culture, which were distributed around foothills, and especially plain area.

Many archaeological sites have been studied and the most of archaeological cultures have been classified, nevertheless very few palynological analyses have been undertaken. Since few researchers have paid attention to botanical history generally, pollen analysis has not developed in particular. The prehistoric vegetation of Northern Vietnam has been poorly understood and the relationship between human and vegetation has not been discussed deeply. This lack of data is a

major impediment to obtain a greater resolution of palaeo-environmental reconstructions in this area. The palynological analysis and new data presented in this thesis must help us to illuminate the vegetation history of Northern Vietnam.

1.1. Aims of the research

In order to understand deeply the ecological or environmental history and the relationship between vegetation and human activities in Northern Vietnam, palynological analyses will be conducted. The purpose is to investigate the pollen assemblages of the Holocene Northern Vietnam with the following primary objectives ;

- To reconstruct the local or regional flora based on the identification of fossil pollen grains and pollen spores.
- To reconstruct past vegetation and vegetation changes.
- To consider the history of relationship between the human and the vegetation in the Holocene Northern Vietnam via the above mentioned analysis.

In nature pollens and spores are produced and then dispersed. Due to the own microscopic size and enormous quantity, they can be scattered from a parent tree widely by dispersal means of wind, water, insect, human, and so on. They are then deposited in sediments. Ancient pollens can be covered by soil sedimentations and preserved in stream or lake sediments for a long term. The abundance of the pollens and spores in such deposits opens up the possibility to reconstruct the past environment precisely (Fig.2).

The archaeological site has the unique soil sedimentation created under the both of human and natural activities. Therefore microfossil analysis from archaeological sediments often provides a basis for paleo-environmental reconstructions. Even if the expected soil sample is unearthed, the preservation condition of microfossils often varies according to species or assemblages. Fossil pollens, phytoliths and diatoms, for example, are best preserved under different sedimentological circumstances (C.J.Lentfer and W.E. Boyd 2000). By maximizing the microfossil catchment areas samples, any assessment of changes to both regional and local paleoenvironments will be enhanced.

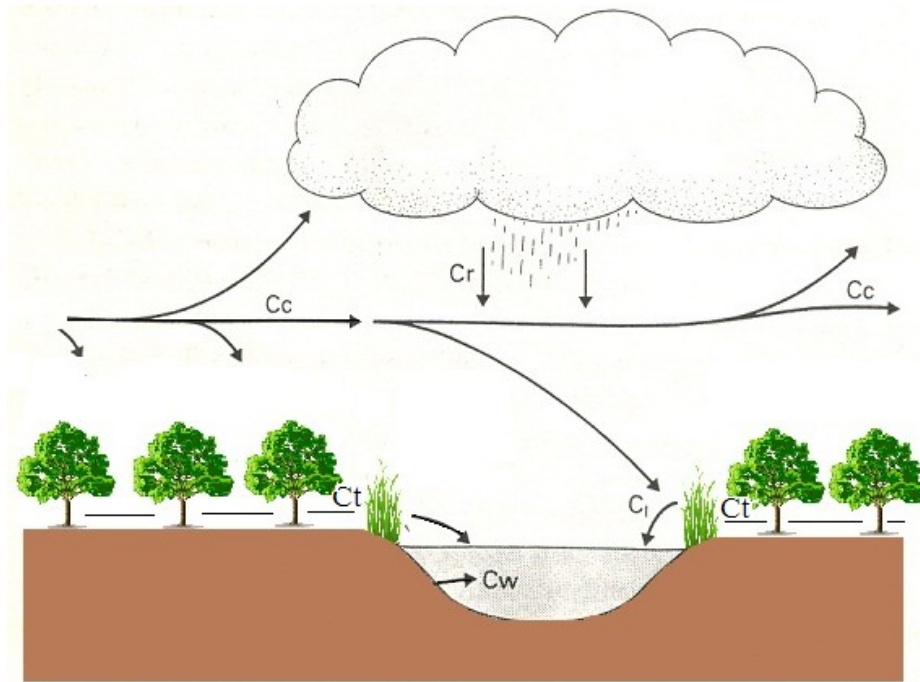


Fig.2. Diagram demonstrating how pollen can be deposited within sediment (adopted from the original in Moore et al. 1991:12)

Cc = canopy component; Cl = local component; Cr = rain component; Ct = trunk space component;
Cw =secondary component, transported by water.

Thus, this study aims to reconstruct the changing process of prehistoric vegetation and the Holocene ecosystem in Northern Vietnam to solve basic problems of ecosystem composition and diachronic change. In addition, the ancient interaction between the vegetation and human activities is evaluated in this study. Figure 3 shows the process and framework inherent in palynological analysis.

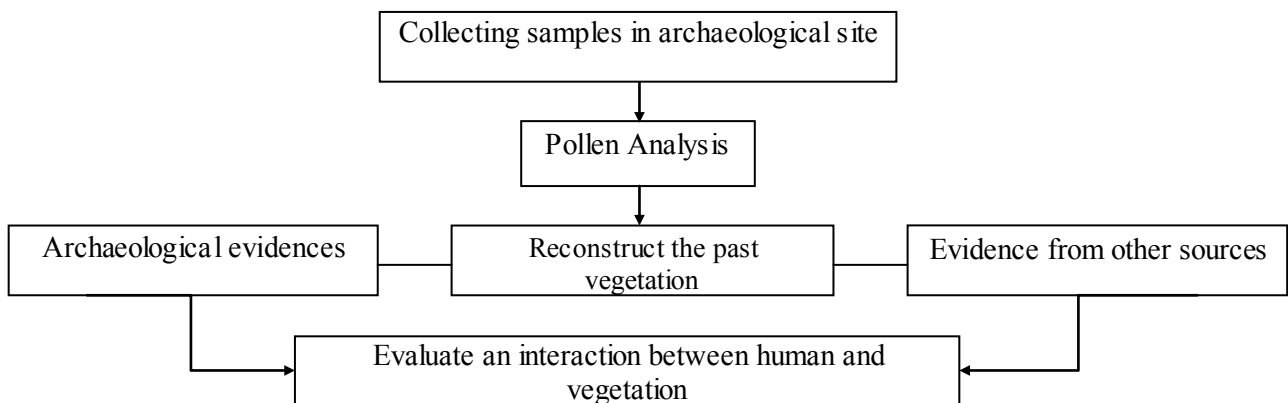


Fig.3: Process of archaeological pollen analysis and how it contributes to larger research

To follow a process shown in figure 3 above, samples are extracted from sediment cores as per specific depositional events that researchers wish to target. The palynological analysis conducted may reveal important characteristics of past ecosystems. Moreover, the data received may be combined with archaeological evidences and large-scale human impact to the environment, particularly in conjunction with the emergency of agricultural activities (Fig.3). The Analysis of palynological assemblages can supposed micro ecosystem, that is condition of plant habitat and the scale of the influence which climate changes gave ecosystem. To complete a paleo-environmental reconstruction, all of geological, botanical, ecological, and archaeological data are required.

1.2. Dissertation Structure

Dissertation title: *“Holocene vegetation and human activities in Northern Vietnam”*

The dissertation comprises five chapters:

Chapter 1:

This chapter provides the general information of Northern Vietnam, and briefly summarizes human settlement of this region firstly. Secondly, the primary aim of this study is presented, moreover, as well as explanation of pollen deposition, preservation and its role in paleo-environmental reconstruction.

Chapter 2:

This chapter reviews current studies on geological features and sea level fluctuations during the Holocene. In addition, A socio-cultural history of the region during the Holocene is also presented while comparing it with present climate and flora ecosystems of Northern Vietnam.

Chapter 3:

This chapter introduces the materials and methods used in this study, including field work, laboratory work, and data analysis.

Chapter 4:

This chapter discusses previous and relevant palynological studies carried out by the author and others. The result of the case study of pollen diagrams at Dong Son site specifically are presented and discussed in this chapter, focusing on descriptions of the pollen zones and diachronic changes to pollen assemblages. The pollination cycles and ecology of the living taxa, that are

considered to represent the nearest living relatives to the fossil taxa recovered from the samples analyses for this thesis are also surveyed.

Chapter 5:

This chapter presents discussions, conclusions, comment and suggestions for the future research. A new paleo-environmental interpretation is presented, taking into account the secondary data as well as the new results presented in this thesis.

CHAPTER 2

NATURAL ENVIRONMENT AND SOCIO-CULTURE HISTORY IN NORTHERN VIETNAM

2.1. Natural setting

2.1.1. Geography setting of Northern Vietnam

The North of Vietnam is so call Tonkin during French cononial, the Vietnamese refer to the area as Bac Bo, located near the intersection of the tropics and subtropics zones, and influenced by three biogeographic regions: Indochina, South China and East Sea. It is bordered by China at GuangXi province to the northeast, Yunnan to the northwest and Laos along its western border (Fig.4). Hilly and montane areas cover up three – quarters of Vietnam and they form a rough semicircle around the northern boundary of Vietnam, within this semicircle lays the extensive Red River Delta (Fig.4). A geological characteristic of Northern Vietnam is complicated, including limestone mountains and deltas, tropical and sub-tropical. This might reflect by the location of Northern Vietnam as mention above (Eleanor J.S et al. 2006).

Northern Vietnam is devided to three sub-regions: Northeast, Northwestern and Red River Delta. The Northeastern region is composed of mainly low ranges which are 600-700 m high on average. The highest peak of the region stands at 2,419 m, while the coastal plain at sea level; Eastern edge of the region is a Tam Dao mountain range (about 1,500m) and sides being extended to the East Sea. In the middle of the plateau (mainly limestone) and the bow are the rivers: Gam, Ngan Son, Bac Son and Dong Trieu flowing in the same direction as the floor system Paleozoic and Mesozoic. Shelf coast of Vietnam with thousands of islands creating a beautiful landscape in the Gulf of Tonkin and Halong Bay was recognized as a World Natural Heritage. In the Northwestern mountainous region, the northward landscape has been gradually uplifting because of tectonic activity. From the east to the west, one first encounters the Hoang Lien Son range 180 km long and narrow run along Da River from the Chinese border to the coast with the highest peak of Fansipan at 3,143m above sea level. Limestone plateau from Phong Tho to Nho Quan with 400km of length and 25km of wide, high above 1000m. The height of mountains is descending to the Son La (600m-700m), but high up at Moc Chau to 1000m. After Moc Chau height is continued to decrease (Nguyen Trong Dieu 1995).

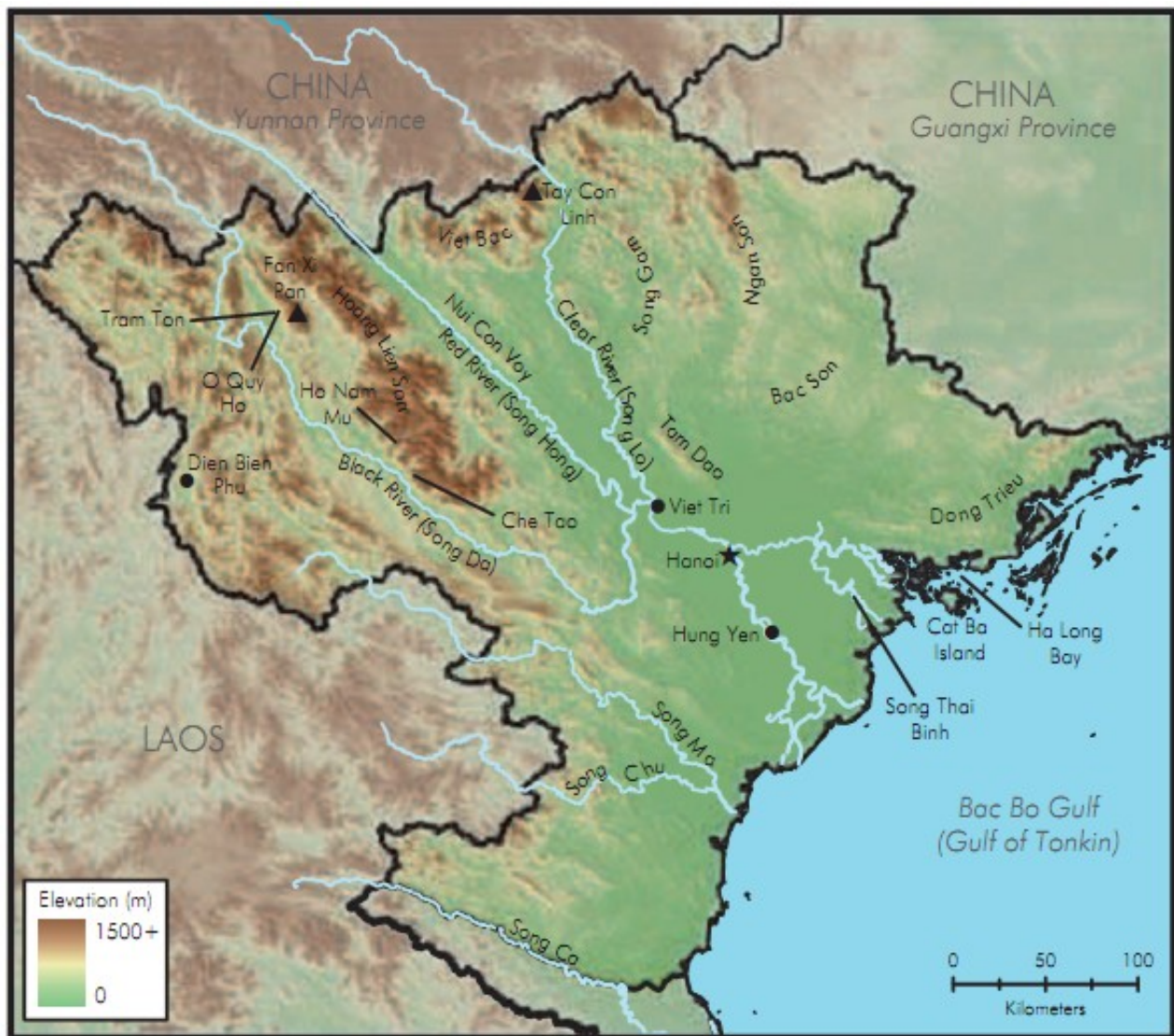


Fig 4: Major feature of topography of Northern Vietnam (Elenanor J. S. et al. 2006)

The geology of the Northern Vietnam was assembled from many geological compositions and then modified deformation and rearrangement through hundreds of millions of years. The cumulative the tectonic movements and the long-term deformation has produced both a complicated topography and a mixture of geologic origins underlying northern Vietnam (Elenanor J. S et al. 2006). Based on of its location, Northern Vietnam has become an important meeting point for communication lines between the Indian and Pacific Oceans and between Asia – Australia (Nguyen Trong Dieu 1995, Elenanor S.J. et al. 2006). This is indicatives of the close relationship between the natural conditions unique to Vietnam and those countries in Southeast Asia and the Pacific region including geological structure, ecosystem, natural resources, man and history.

Red River Delta is located to the northwestern part of the Gulf of Tonkin, which is one of the largest deltas in Vietnam after the Mekong River Delta. This Delta formed by two major river

systems is the Red River and Thai Binh River, with a total area of about 17,000 km². The Delta area is surrounded by low mountains (about 50 to 70 m above sea level) and relatively flat, with an average elevation of less than 25m and less toward the sea. The topography created favorable conditions for inhabitants and founded the village. Red River Delta is home to the highest population density in the country. Agriculture plays an important role in the whole area of the plain and rice is the main crop (Nguyen Trong Dieu 1995; Y. Saito et al. 2004).

As the same to the Northern Vietnam, Red River Delta (RRD) area has a complicated geological history with up and down movements, transgressions, erosion, and stream activities that formed the alluvial sediments. The result of these geological processes is a relatively thick Quaternary formation with loose and altering sediment beds, often containing organic material. In general, the Quaternary formation in RRD can be divided into two sequences: (i) the upper part is composed of fine sediment clay, sandy clay, and fine sand; and (ii) the lower part contains gravel with cobbles and coarse sand. Most of the land belongs to the Neogen and Quaternary sedimentary era and runs northwest-southeast (Mathers et al. 1996; Tanabe S. et al. 2003 a,b). Quaternary sediments had been deposited since the last glacial maximum composed of three formations; the Vinhphuc, Haihung, and Thaibinh in ascending order (Fig. 5) (Mathers et al. 1996; Tanabe et al. 2003).

Holocene sediment of the Red River Delta has a thickness varying from 1-2m to 40-50m but it distributed over 80% of the surface of plain (Doan Dinh Lam 2004). The Red River Delta is considered to be the result of the process of composition of river, marine and sediment mixture of river - marine, river - swamp, marsh - marine,...Research on the history and development of the delta in Holocene mainly refers to the perspective of the impact of Flandrian transgression progress. Holocene sedimentary evolution problems as well as the structure of deltaic sediments have not been solved explicitly (Doan Dinh Lam 2005).

On basic of geomorphology and hydrodynamic process, Mathers et al. (1996) has divided the Red River Plain into wave-dominated system on the southern coastal plain, tide-dominated system on the northern coastal plain and fluvial-dominated system in the landward portion. The sub aqueous delta was divided into delta front and pro delta on the basis of its sub aqueous topography, and the delta front is further subdivided into delta front platform and delta front slope (Zhen Li 2006a, Saito et al. 2004).

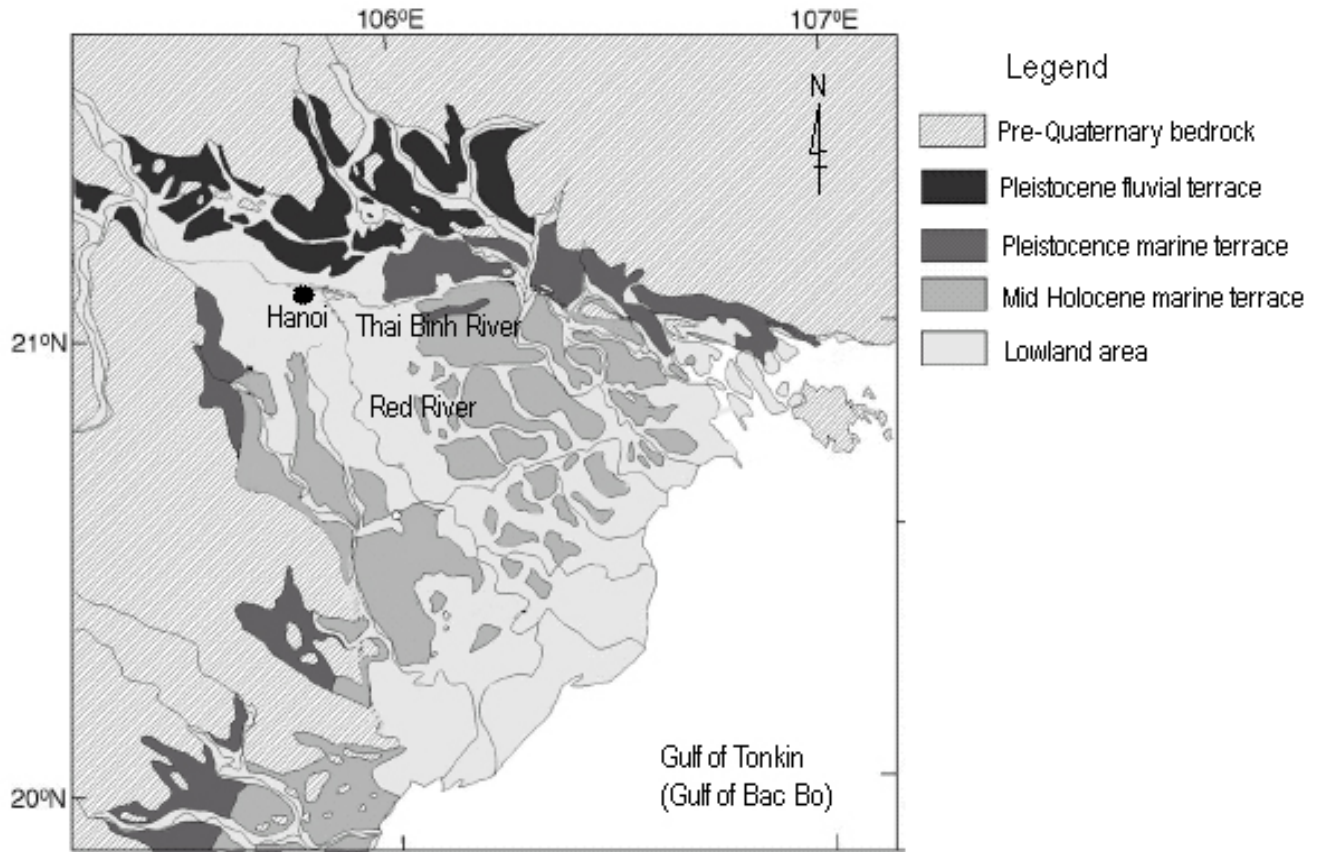


Fig 5: Geological Map of the Quaternary in the Red River delta and adjacent area
(Tanabe et al. 2003a)

2.1.2. Current Climate and regional vegetation

Northern Vietnam is located in the humid tropical zone where Southeast Asian monsoon influences, therefore both temperature and rainfall is noticeably seasonal. Cold, humid winters with occasional light rains from November to April, and frost is not unusual in high mountain regions. Summers are hot, muggy, and rainy from May to October. The mean annual precipitation is from 1,500 to 2,000mm. The hottest months in the north are June, July, and August, when humidity reaches 80 to 100 percent. The annual average temperature in the Northern Vietnam at Ha Noi capital is 23°C, resulting in a dense covering of vegetation from tropical and broad-leaved forests to coniferous forest (Nguyen Trong Dieu 1995, Elenanor J.S et al. 2006). (Table 1)

Table 1: Climate stations in northern Vietnam (Elenanor S.J. et al 2006)

Name	Elevation (m)	Temperature oC		Rain fall (mm)		Dry month	Wettest month
		Annual average	Range monthly averages	Annual average	Range monthly averages		
Bao Lac	258	22.2	14.5-27.6	1247	20-232	4	July
Cao Bang	258	21.6	14-27.3	1443	16-267	3	Aug.
Bac Quang	74	22.6	15.1-27.7	4802	68-901	0	June
Hoang Lien Son	2170	12.8	7.1-16.4	3552	64-680	0	July
Mu Cang Chai	975	18.7	12.4-22.6	1813	17-371	2	July
Lang Son	258	21.2	13.3-27	1392	23-258	3	July
Mong Cai	7	22.7	15.1-28.4	2749	38-559	0	July
Tam Dao	897	18	10.8-23.1	2631	38-525	0	Aug.
Phu Yen	182	22.8	15.7-27.8	1537	12-305	4	Aug.
Song Ma	302	22.4	16.1-26.4	1185	10-255	5	Sept.
Ha Noi	5	23.5	16.5-28.9	1674	18-314	6	Sept.
Hong Gai	87	23	16-28.5	1894	20-430	4	Aug.
Kim Boi	100	22.8	15.7-28	2256	23-433	3	Sept.
Thanh Hoa	5	22.6	17.1-29	1742	25-395	4	Sept.

Almost one – third of the total land area is under tropical evergreen and sub-tropical deciduous forest of oak, beech, chestnut, pine and ebony. Bamboo is widespread both in undergrowth of forests and along rivers. Mangrove forests are prevalent in the tidal coastal plains and savanna type grass and shrubs cover the highland and plateau of the Southwest (Encyclopedia Britannica, 1998). On the other hand, due to it favorable geographic situation many exotic species have migrated from neighboring countries and region including the Himalayas, Southern China, Hainan, Taiwan, the Philippines, India, Malaysia, Laos, Cambodia, and other places (Nguyen Trong Dieu 1995; Thai Van Trung 1978).

The regional vegetation as preserved in several natural forest protection areas is typical of tropical seasonal rain forest and consists mainly of tropical moist semi-evergreen and tropical green forests (Zhen Li et al. 2006). A dense canopy is formed by evergreen members of Fagaceae family (*Castanopsis*, *Lithocarpus*), Lauraceae (*Cinnamomum*, *Lindera*, and *Caryodaphnophis*),

Anacardiaceae (*Dracontomelum*), Meliaceae, Moraceae (*Artocarpus*, *Ficus*), and Tiliaceae (*Kydia calicina*). Deciduous trees include *Terminalia myriocarpa* and *Pometia pinnata*, *Euphorbia*, *Carrallia lancaefolia*, and *Dimerocarpus brenieri*. Species of the Urticaceae and Orchidaceae are dominant in the lowest stratum of the forest. On the mountain summits, *Sasa japonica* is dominant. Common species of the swamps and foothill forests include the upper stratum species *Dracotonmelum duperreanum*, *Aglaia gigantean*, *Duabanga sonneratioides*, *Largetroemia balansae*, *Pterospermum*, *Cinnamomum*, *Caryodaphnopsis tonkinensis*, and *Peltaphorum tonkinensis*. Lower stratum species: *Engelhardtia spicata*, *Gironniera subaequalis*, *Garcinia*, *Alphonsea*, and *Ardisia tonkinensis*.

The undergrowth is composed of herbaceous plants, including members of Rubiaceae, Araceae, Commeliaceae, and Urticaceae, and numerous ferns. In marshes and ponds, aquatic plants include *Nymphaea*, *Lotus*, *Valissneria spiralis*, and *Myriophyllum spicatum*. The principal vegetation in the estuary marshes includes *Phragmites*, *Cyperus*, and algae such as *Rhizosolenia*, *Chaetomorpha*, *Clenophora*, *Enteromorpha*, *Oedogonium*, *Pterothamnion crispum* and *Gracilaria*. The natural mangrove vegetation of the delta are mainly of variety of species, such as *Sonneratia caseolaris*, *Kandelia candel*, *Aegiceras corniculatum*, *Avicennia spp.*, *Rhizophora stylosa*, *Bruguiera gymnorhiza*, *Acanthus ebracteatus*, and *Derris trifoliata*. However, the natural mangrove forests have long been replaced by much simpler, planted communities consisting mainly of Bamboo, shrubs, and grasses, especially *Imperata cylindrical*, *Melastoma candidum*, *Rhodomyrtus tomentosa*, *Cratocylon*, *Macaranga*, *Lygodium microphyllum*, *Pinus*, *Trema orientalis*, *Miscanthus sinensis*, and some members of the Euphorbiaceae (Zhen Li et al. 2006; Phan Nguyen Hong 1999)

The principal land use throughout the delta is for the cultivation of paddy rice. Saline aquaculture is practiced along the coast. Some upland cultivated plants such as *Ipomoea*, *Colocasia esculenta*, and *Dioscorea* are cultivated mainly in scattered in upland or mountainous areas (Zhen Li et al. 2006).

2.1.3. Sea level change in Holocene

When research on habitat of prehistoric in Vietnam in particular and Southeast Asia in general, archaeologists particularly interested in the oscillation phases of sea level in the past. The fluctuations of the sea level are not only the change in geology, but also is an important factor plays a major role in the formation history of the Red River Delta and North Central of Vietnam. The geological upheaval has significantly changed the topography and geomorphology of the territory of Vietnam led to the change of residence of human beings and other creatures living in the area.

Environmental change events have created a pressure rise to an innovative new process that is generated in agriculture.

During the last glacial maximum, about 18,000 – 20,000 yr BP, the most recent maximum extent of the glaciers, appear to be among the most extreme of the past several million years. Precipitation in Asia fell to 30 to 50 percent of current levels, and mean temperatures were 4°C–7°C cooler. Sea levels fluctuated widely and at times were as much as 120 m lower than present sea level (Fig.6) (Hori et al. 2004; Tanabe et al. 2003; Nguyen and Tran 2009; Elenanor S.J. et al 2006). It rose to approximately 50, 30, 15, and 5 m below present sea level at about 11, 10, 9, and 8,000 cal. yr BP. (Tanabe et al. 2003b; Funabiki et al. 2012), respectively causing the shoreline to move rapidly inland. Sea levels also rose due to periodic bedrock erosion, inundating surrounding estuaries. Estuarine deposits then covered deposits and intertidal marshes formed at this time, with shallow bays formed by sea level rise during the Holocene marine transgression in ca. 6,000 yr BP.

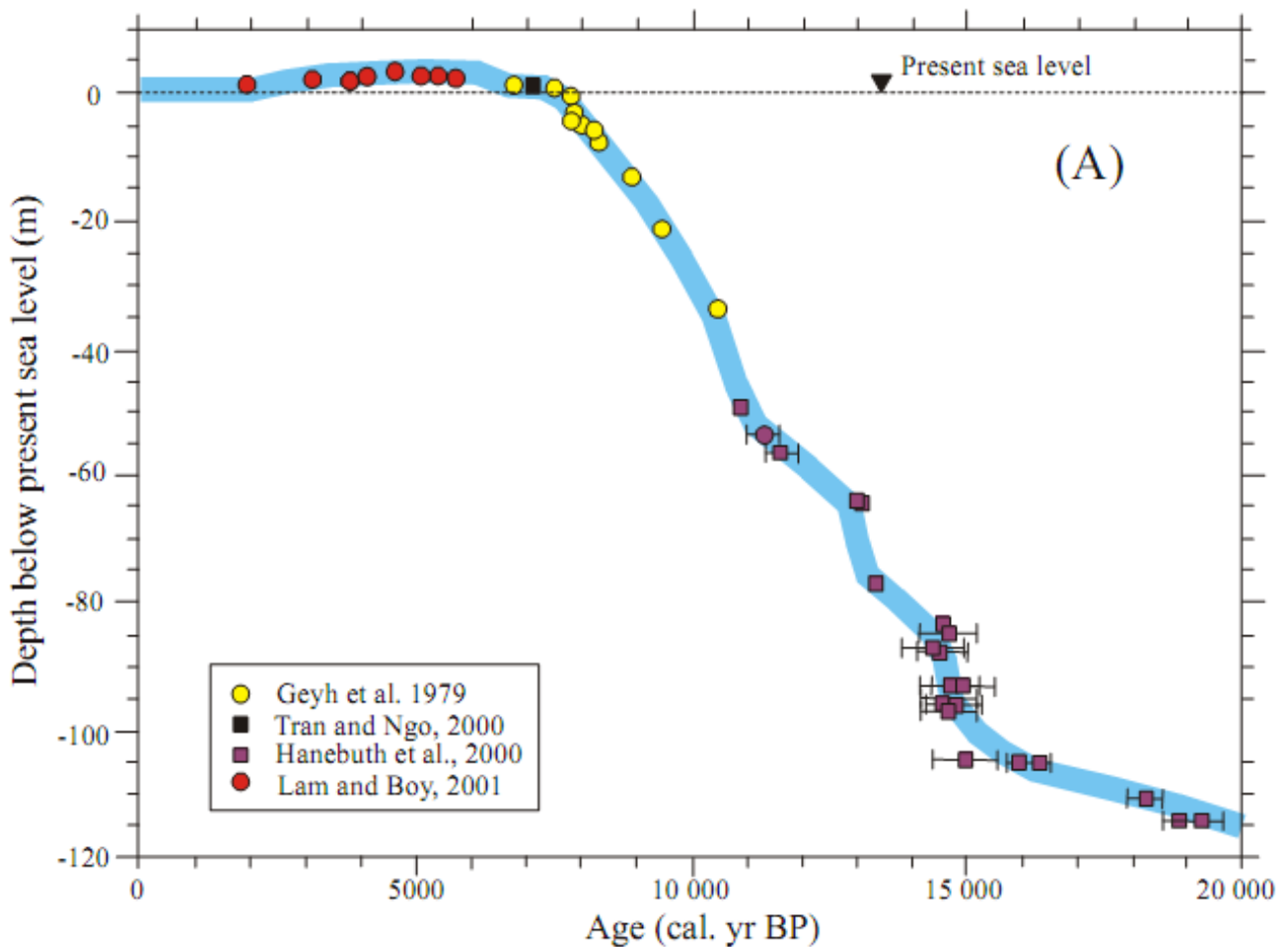


Fig.6. Sea level curve for the western margin of South China Sea during the past 20,000 yr BP (Nguyen T. H.L 2006: 16)

Researched on the evidence for sea-level changes since the last glacial maximum, based on the marine notches in the Ha Long Bay, Ninh Binh areas, the mangrove clay at Tu Son (Bac Ninh), and the archaeological deposits (shell middens) in Da But (Thanh Hoa) by Tanabe et al. (2003) and Boyd and Doan (2008) shows that the sea was at its present sea level around 7,000 yr BP, then rose further to more +2 to +3 m above mean sea level between 6,000 and 4,000 yr BP, and after that gradually fell to present level (Fig. 7) (Tanabe et al. 2003b). The rate of rise of sea level in this period is quite high (Doan and Boyd 2001; Hori K. et al. 2004; Tanabe et al 2003 a, b). Study on speed of sea level rise, Doan and Boyd stated that from 10,000 to 9,000 yr BP, the rate of rise of sea level of 10-12 mm/year, at about 7,000 yr BP speed rise of sea level to about 2-4 mm/year and at the end of the early Holocene, the rate of rise of sea level to about 1-2 mm/year and gradually approaching to 0 (Doan and Boyd 2001).

Absolute date and the general characteristics of sediment of ND1 core, LK DT (Tanabe S. 2003a, b), LK CC (Hori K et al. 2004) has demonstrated of estuaries bays on the Red River Delta area in the early Holocene, by the presence of oyster (*Ostrea*) at Luong Dong, Vu Ban (Nam Dinh) with wide distribution at the depth of 0.5-1m, which is date of $6,800 \pm 100$ yr BP. It indicated that about 6,500-7,000 yr BP already exist a fairly typical estuary mode.

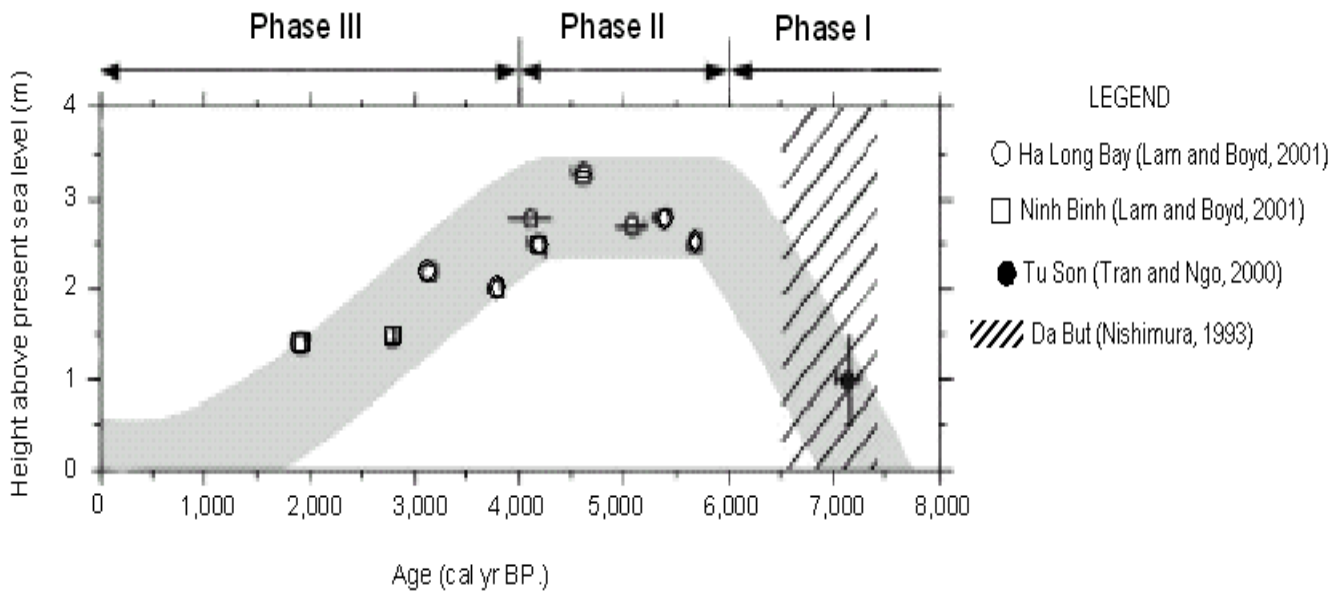


Fig. 7: Sea level curve in the Red River Delta region during the last 8,000 yr BP (Tanabe et al. 2003)

At around 6,000 yr BP, the entire central of the Red River Delta was drowned in the sea. The presence of sediment was formed by alluvium from the late - middle Holocene demonstrated that sea level quite stable in a relatively long time. The increase of sediment discharge during this period was a result of anthropogenic deforestation of the upper reaches of the Song Hong drainage basin (Funabiki et al. 2012). This result coincides with the result that Haruyama (Haruyama et al. 2001) been described about the history of the formations and development of Holocene deposits within the limits of the northern delta. This time can also be considered as the boundary between the early and late Holocene.

At about 4,000 yr BP, the deltas are constantly expanded over the sea. They are marked by sand dunes along the coast about 2-3m height above sea level (Tran Nghi et al. 1991; 2000). At about 3,000 yr BP, paleo-geography also changes very powerful. Sea level had lowered and the coastline was pushed farther toward the sea. In the process to the sea, the rivers and tributaries have moved the flow of many times. Under the action of waves, tides, smooth material is taken away, and the raw materials will be retained, forming strips of dunes running parallel to the shore. There are also many other reasons why the river branches move like tectonic activity, material supply changes due to changes in upstream or due to climate change. The process of moving river can be clearly seen in the river in Phu Ly, Van Lam, and Day River (Doan Dinh Lam 2008).

At approximately of 2,000 cal.yr BP sea level to about +1.5 m (Boyd and Doan 2004), some authors suggest that at about 2,500-2,000 yr BP sea level lower than mean sea level. This progress to create a vast plain, so that the relics of the Dong Son culture has found a lot not only in the land but also in the coastal province of Ninh Binh, Hai Phong, Thai Binh and Thanh Hoa. It was clear that at about 3,000 yr BP, the prehistoric peoples who live and reside in Red River Delta.

Tran Nghi et al. (1991) have researched on the evolution of sediments in the Red River Delta after Flandrian transgression progress. These findings suggest that sediments had change very quickly from marine to the delta and at the same time the coastline also changes. In Red River Delta, Holocene sediments deposited when sea level lowered to about 1,000 years ago when Ly Dynasty began to build dikes along the Red River. This means that sediment start concentrated mainly in the river about 1000 years ago. It deposited directly in the river bed, therefore the outside of the dike currently is higher than the surface of the rice fields inside.

Susumu Tanabe et al (2003a) have generalized changes in sea level since the last glacial maximum and divided into three phases (Figure 7): phase I (from 9,000 to 6,000 cal. yr BP), phase II (from 6,000 to 4,000 cal. yr BP), and phase III (from 4,000 yr BP. to present). In phase I, the sea

level rise from under 15 m to +3 m higher than sea level at a rate of 6 mm/year. In phase II, the sea level balance and stability. Phase III, the sea level began to lower from +3 m higher than down to the present sea level with an average speed of 0.6 ± 0.1 mm/year (Tanabe et al. 2003a). Meanwhile, Vu Quang Lan (2004) argues that during the Holocene, sea level consists of 3 phases: Phase I (from 10,000 to 6,000 yr BP) the sea level is higher than mean sea level at +4.5 to +5 m; Phase II (from 6,000 to 4,500 yr BP) sea level remained stable at +4.5 to +5 m above present sea level; Phase III (about 4,500 yr BP to present) sea level and lower reaches sea level currently about 1,000 years ago (Vu Quang Lan 2004).

2.2. Socio-cultural history in Northern Vietnam

Since the late Pleistocene, in Northern Vietnam, the development stages of human culture took place continuously was called Son Vi Culture (late Paleolithic). In general, Son Vi culture exists around 30,000 years ago, the habitants of Son Vi culture were hunter-gatherers whose tools were pebbles flaked only on the edge. They lived on open slope of hill and mountain area. The chronology of archaeological culture in Northern Vietnam is in table 2 below:

Tab.2: The chronology of archaeological culture in Northern Vietnam

Epoch		Culture	Date (uncal. yr BP.)			
Stone Age	Late Paleolithic	Nguom, Son Vi	33,000 to 11,000 yrBP	33,000 to 12,000yrBP		30,000 to 10,000 (common from 20,000 - 11,000yrBP)
	Neolithic	Hoa Binh – Bac Son	12,000 to 6,000 yrBP	12, 000 to 7,000 (some sites 18,000)		
		Quynh Van, Da But, Hoa Loc, Ha Long	8,000 to 3,500 yrBP	7,000 to 4,000yrBP	6,500–4,500yr BP	
Metal Age	Bronze Age	Phung Nguyen	4,200 to 3,000 yrBP	4,200 to 3,000yrBP	4,500–4,000yr BP	4000-2700yrBP
		Dong Dau – Go Mun	3,500 to 2,000 yrBP	3,500 to 2,400yrBP	3,100–2,400yr BP	
	Iron Age	Dong Son	2,700 to 2,000 yrBP	2,700 to 2,000yrBP	2,500–2,000yr BP	2700-2000yrBP
References			<i>Ha ed., 1998; Ha ed. 1999</i>	<i>Nguyen and Pham, 2004</i>	<i>Nishimura & Nishino, 2003</i>	<i>Tran and Lam 2009</i>

Settlement sites distributed in Bac Bo Plain have been taken important role of pre-historical period. Nishimura and Nishino (2003) collected archaeological data in the Red River Plain and reported that up to now 600 prehistoric archaeological sites and so far have been examined, among

them about 145 sites belong to Paleolithic and Hoabinhian, 207 sites correspond to Neolithic age and a numerous 276 sites belong to Metal age (Fig.8 and 10).

2.2.1. Neolithic culture

The researches on the Neolithic environment of Southeast Asia and Vietnam in particular made it possible for archaeologists to understand the dramatic transformation of the topography, geomorphology and the living environment (Fig.8). This is the impacts of several phases of sea level fluctuation in the past. These geological phenomena had a strong effect on the distribution of Neolithic sites in North Vietnam (Fig.6, 7).

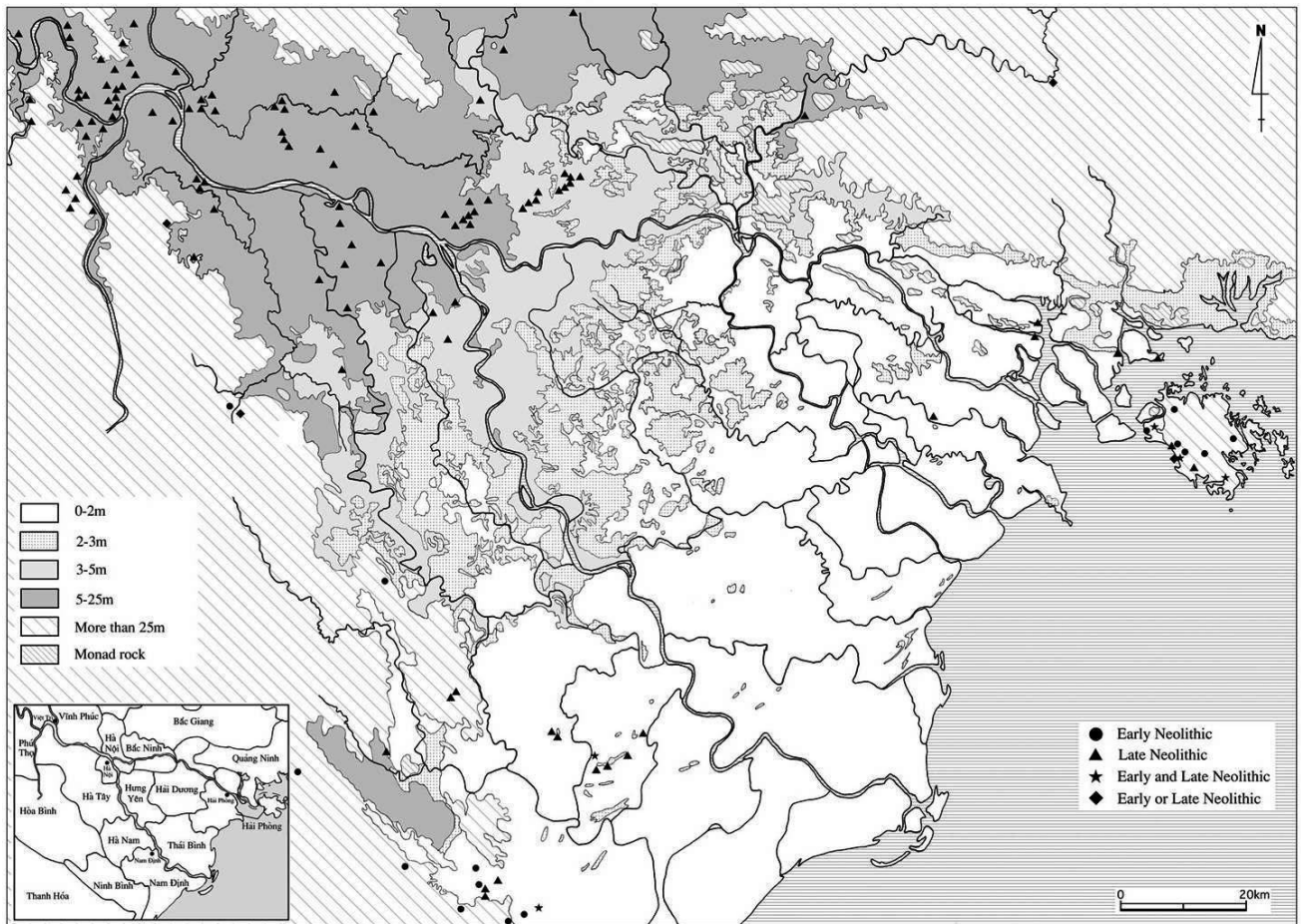


Fig. 8: Distribution of Neolithic sites in the Red River Delta (Nishimura and Nishino 2003)

At beginning of Holocene, Hoa Binh culture, the culture was developed from Son Vi culture existed around 12,000 to 7,000 yr BP. (some sites the date reached 17,000 – 18,000yr BP.) which is distributed wildly not only in Vietnam but also in Southeast Asian, especially within the floral

bioregions adapted to a tropical and humid climate pattern. In contrast with Son Vi culture, settlement of Hoa Binh culture and its final period was called Bac Son culture mainly settle in limestone cave and rock shelter. It may cause of the sea fluctuation that mention above. That is why we can be found early Neolithic sites in the mountainous area of Hoa Binh, Thanh Hoa, Ninh Binh, Yen Bai, Lao Cai provinces,...some sites are distributed in the Hai Phong, Cat Ba Islands, which about or higher than 25 m above sea level (Nishimura and Nishino 2003). In the late Neolithic, archaeological sites can be found at the plain and coastal area. The absence of the distribution of the Neolithic sites in the central plain may reflect the presence of seawater or brackish water in lower areas (Fig.8).

2.2.2. Pre -Dong Son culture

The Pre - Dong Son culture was dated for about 4,500 yr BP to 2,500 yr BP (Nishimura and Nishino 2003; Ha ed. 1999; Funabiki et al. 2012), when sea levels were lower, the coastline was receding, and by extension more favorable conditions for the residents settled. This period is characterized by the appearance of copper and metallurgical engineering, pieces of slag and rust and found proved for these activities. Metal appearance marked a major turning point in the evolution history of the inhabitants of the Pre-Dong Son culture.

The archaeological sites of this period have played an important role in the process of creating the prehistoric cultural in Northern Vietnam. These sites distribution on the Pleistocene and Holocene terrace in the range from 5 to 20 m above the sea level, mainly distribution and development along the major rivers such as: the Red River, Ma River and Ca River. Along with the development of this culture is the expansion of habitat in the delta areas where are most affected by alluvial, wave and tidal systems. A number of sites were distributed in the lowland of the Delta region, on the natural levees and sand dunes about 2-3m above sea level. Cultural layer of many archaeological sites showed human activities for a long time.

Based on the recent discoveries, Vietnamese archaeologists have defined three stages of development in the cultural process in Bronze Age on Red River Delta. The process of men's control of the delta has been also coexisted with the natural expansion of the Red River, Ma River, Ca River Deltas and in some remote mountain areas or hilly regions.

In the Red River Delta, the Pre-Dong Son culture was established three successive stages, named after Phung Nguyen-Dong Dau-Go Mun. In fact, this is 3 stages of continuous development of Bronze period in Red River Delta. The continuous show on the typology of pottery, jewelry and bronze objects. Archaeologist have been found clearly evidence from the stratigraphy at Dong Dau

site (Vinh Phuc), it shows the Phung Nguyen culture in lower layer, Dong Dau culture in the middle layer and Go Mun culture in upper layer. Or at Dinh Trang site (Hanoi), there are 3 cultural continuing develop as Dong Dau in lower layer, Go Mun in middle and Dong Son in upper. Thanks to the continue development in these sites, archaeologist had rebuilt the cultural development stage from Pre-Dong Son to Dong Son culture in the Red River Delta.

Phung Nguyen culture

The Phung Nguyen culture (4,000 - 3,500 yr BP) is considered a cultural opening for the Bronze Age of Vietnam which is development from Neolithic, when people have known polished quadrilateral axes. The ruins of Phung Nguyen culture sites are distributed on the slope hill, hills, along major rivers, such as: the Red, Da, Lo, Thao rivers. Some sites distributed in lowland and coastal areas (Ha Van Tan ed., 1999: 23-25), suggesting that the sites are mostly distributed on the late Pleistocene sediments. These sites with cultural layer thickness and the dense concentrations of archaeological sites prove Phung Nguyen residents have long gathered as villages.

Up to now, about hundred of Phung Nguyen archaeological sites have been studies, with clearly characterized by the stone and pottery objects was distributed in the large area of the Red River Delta. The Phung Nguyen inhabitants use of ornaments made of nephrite by the high-skilled craft techniques (Nguyen Ba Khoach 1980), particularly clearly seen at Trang Kanh site (Hai Phong), the manufacture of stone site with a wide range of nephrite artifacts or at a cemetery of Lung Hoa (Vinh Phuc) the grave goods are included bracelets, rings, beads, adzes and pottery. This distinction suggests social ranking based upon the importance of jewelry to the culture.

Another characteristic of this culture must mention is the presence of agriculture. The stone hoes had big size, wide blades, some hoes special shape call "plowshares", quadrilateral axes, shoulder axes were found. The pollen of rice (*Oryza sativa*) presented in the cultural layer at Trang Kanh (Hai Phong) (Nguyen Duc Tung 1970) and Hoa Loc (Thanh Hoa). Burnt rice found in Phung Nguyen cultural layer at Dong Dau site (Vinh Phuc) demonstrated that agriculture thrives. Agricultural tools such as sickles are still using in some areas in Northern Vietnam. Beside, bones of pigs (*Sus domestica*), dog (*Canis spp.*) are increasingly found in archaeological sites, such as Lung Hoa and Dong Dau sites (Vinh Phu). Especially, at Hoa Loc site animal bone assessment shows that animal domestication bone occurred 27.93% (Ha Van Tan eds. 1999: 172). Many weight fishnets and fish bones found at Phung Nguyen, Dong Vong, Trang kenh, Bai Tu and Hoa Loc sites. The threads of that evidence showed residents of this period besides rice cultivation but also hunting and fishing to complement the food.

With the advantage of residing on a large scale of the Phung Nguyen inhabitant, the craft has developed based on the available materials around their habitat. The craft processing have reached the level of technical perfection, with a very diverse collection of bracelets with different sizes reflects the needs of widely used, as we found the large number of drills in Trang Kanh site (Hai Phong), stone workshop as Bai Tu (Bac Ninh), Con Chan Tien, Dong Khoi (Thanh Hoa), unfinish bracelets found in Hong Da (Vinh Phu), Con Cau. Ceramic was made in high technic and decorated with harmonized patterns show a high technical level, particularly very diverse forms, exquisite with many decorative scheme for geometric value, or “s”, moon, sun, seeds, flowers, very soft curving waves,...by their aesthetic thinking they have to re-do all the exists around. It shows relationship with nature to simulate in ceramic pattern (Ha Van Tan ed. 1999) (Photo 1).



Photo 1: Phung Nguyen quadrilateral axes (Source: Institute of Archaeology)



Photo 2: Phung Nguyen pottery (Source: Institute of Archaeology)

Dong Dau culture

At the end of the Phung Nguyen culture, Dong Dau culture (3,500 to 2,800 yr BP) was formed when the shoreline shifted farther, the geological then gradually stable therefore Phung Nguyen residents started moving down to the lower area and settled. Dong Dau culture is known by the name of Dong Dau site (Vinh Phuc province). This site was first discovered in 1962. The relics of the Dong Dau culture basically coincides with the distribution of Phung Nguyen culture mainly in the hilly areas of northern midland plains, beside lakes, along the the Red, Lo, Da and Duong Rivers basin but expanded to the plains. Based on the thickness of the culture layer from the archaeological

sites, we can see that Dong Dau inhabitants also live in the village. At many Dong Dau sites researchers found traces of yellow clay soil compaction and many small holes suggestions that these are pillar houses.

The main economic activity of Dong Dau inhabitant was farming. The evidence was the burnt rice grain remains found at Dong Dau and Thanh Den sites. Besides, hunting is still well developed showed by the animal bone remains at the archaeological site like bones of dogs, chickens, pigs, elephants, cattle, deer, aquatic animal like shrimp, crab, fish, and turtle were also exploited. This shows that the environment of Dong Dau residents very close to rivers and the jungle. In general, trace of fauna and flora in the the Dong Dau culture enriched than Phung Nguyen culture (Ha Van Tan eds. 1999:124)

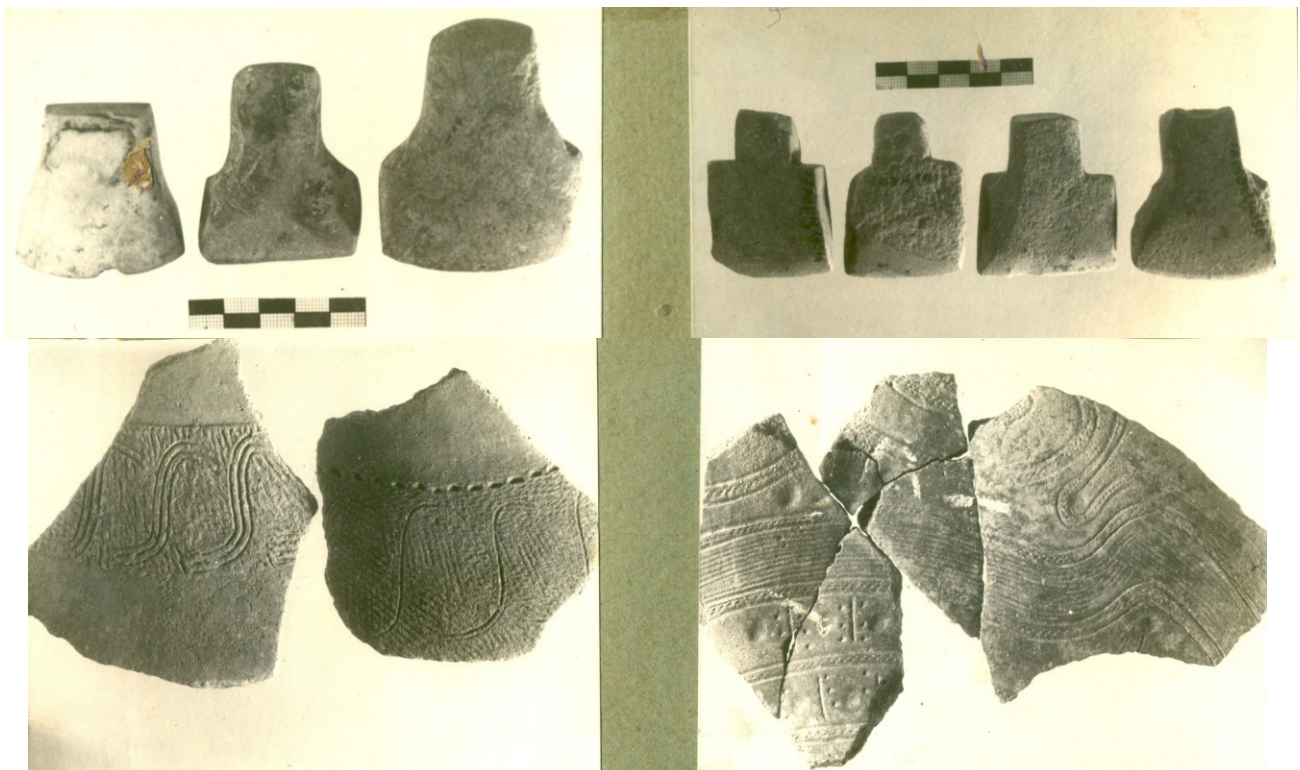


Photo 3: Dong Dau culture stone axes and pottery (Source: Institute of Archaeology)

The characteristic of the Dong Dau culture is developed of metallurgical engineering. The appearance of metal brought significant change to local material and socio-cultural lifeways, and it is a rather clear point along the prehistoric trajectory in Vietnam. Through excavation, many artifacts have been unearthed, and some of them have multiple functions, such as: arrows, spears, knives, axes, fish hooks. At sites of Thanh Den, Dong Dau (Vinh Phuc), Dong Den, Dong Lam and Doi Da... archaeologists have found many pottery (Photo 3), furnaces and casting molds are mostly made from

clay mixed with rice husk. Besides the bronze and pottery artifacts, stone production still existed and occupies a significant position. Dong Dau culture residents still value and used stone tools such as axes, chisels, arrow, jewelry such as bracelets, earrings. However, the quality of materials and processing techniques seemed to be somewhat less because they are not focusing as previously (Ha Van Tan eds. 1999: 97).

Go Mun culture

The Go Mun culture dated around 2,700 – 2,400 yr BP (Nishimura and Nishino 2003) developed directly from the Dong Dau culture, so that the distribution range of the Go Mun culture has certain overlap with the distribution of the Dong Dau culture. The archaeological sites of Go Mun culture pretty focused and mainly distributed in the low hills, and the midlands of Phu Tho, Vinh Phuc provinces, along the basin of the major rivers like the Red, Da, Duong, Day Rivers. And expand to plain such as some sites in the lowlands were studied in Bac Ninh, Bac Giang provinces and Ha Noi (Ha Van Tan eds. 1999: 126-130). We have found the burnt rice grains at Dong Dau and Thanh Den sites. Besides, pollen analysis from those sites found pollen of *Poaceae*, *Ipomoea* sp., *Citrus* sp. (Nguyen Thi Mai Huong 2002, 2003). Based on these facts, many researchers believe there may have planted cereals, root crops and fruit gatherers combination with gathered around the area of their residence. The remains of animal bones including of pigs, cattle, dogs, cows, elephants, deer, crabs, fish, snails, turtles showed that hunting and catching crustaceans in rivers and lakes was still supplies mainly food. It is also suggested that many pig and dog were domesticated at that time (Ha Van Tan eds. 1999: 126-150).

Go Mun culture's pottery was diversified into types of container, cooking vessel, sinker of fishing net, spindle, and so on. These were burnt at the high temperature. Pottery wall became to be thinner from early to late development stages. Pottery decorative motifs were also very diversified, which made up by scoring and printing mainly. It can be said the pottery of the Go Mun culture developed more than the pottery of Dong Dau culture in both materials and forming techniques, firing and style to create the pattern (Ha Van Tan eds. 1999: 133-137). Stone has occupied an important position in the lives of Go Mun culture residents but reduce in number, it can cause by the techniques of metallurgy were quite popular and widely used. However, Go Mun people had creating very beautiful stones jewelry like earrings, bracelets with many different styles. The stone tools such as axes were reserved long tradition of ancient people from the Phung Nguyen culture through Dong Dau to Go Mun culture.

Striking features of the Go Mun culture is the diversity of the bronze objects, and the bronze tools occurred higher number than stone tools. If in the Dong Dau culture, there are only 10 types of bronze artifacts, and then here is a double type, such as: axes, spears, darts, and arrows, spearhead hooks, carving knives, hammers, rattles, bracelets, and rings. It shows Go Mun residents have high technical skills in bronze casting. However, most of bronze objects have not been decorated. Only the Dong Son culture techniques has, its created patterns on the new map to the development and marked the highest development of metallurgy and metalworking kind.

Pre-Dong Son culture distributed in mountain area

In the mountainous area of Northern Vietnam about 20 sites belong to late Neolithic - early Metal age have been found (Ha Van Tan eds. 1999: 153). These sites were randomly discovered. They majority concentrated is located in the limestone areas, provinces of Lang Son, Ha Tay, Hoa Binh, Lai Chau, and Son La. At these sites the trace of early Metal age is mixed with the previous cultural layers, mainly Son Vi, Hoa Binh and Bac Son culture. Most of the sites belong to Pre-Dong Son culture which is distributed in the northern mountainous area and mostly in the cave, very small number of open sites is distributed. Overall, these sites in each region have its own characteristics, but have similar features that they have certain relationships with residents who live in plain and coastal area table 3 (Ha Van Tan eds. 1999: 153-154). We have not yet discovered metal object in those sites, may be due to the low level of metal mining or demand of using metal object is not high at that time.

Tab.3: Distribution of Pre-Dong Son archaeological sites in mountain area in Northern Vietnam(Ha Van Tan ed. 1999)

Province	Number	Cave site	Outdoor site
Lang Son	8	Tham Khoach, Dong Thuoc, Lang Trang, Con Ke II, Na Con, Ban Hau, Ba Xa and Mai Pha	
Hoa Binh, Ha Tay, Ninh Binh, Thanh Hoa	3	Cho Ganh, Hang Khoai, Chom Cheo	
Son La	14	Ban Mon, Sap Viet, Ban Buon, Tham Khuy, Ban Tham, Hang Dien, Thoc Kim, Nui Mo, Chieng Sai, Hang Puoc	Ban Thon, Ban Pho, Ta Khoa, Pa Mang II, Dan Lanh
Lai Chau	1	Nam Tun	
Tuyen Quang, Ha Giang	1	Binh Ca,	Lo Gach

So we can see cultural stratigraphy evolution of the Pre-Dong Son culture period, from Phung Nguyen, Hoa Loc and some other cultures, human began to learn metal using. Metal appearance had brought a great change in their life. It was followed by Phung Nguyen culture which existed on the same territory which is corresponds to the end of the Bronze Age. Dong Dau culture

offered a greater variety of bronze artifacts, like spearheads, arrowheads, fish hooks and sickles - which indicate an upsurge in metal making, particularly in the manufacture of bronze tools. At Thanh Den site (Me Linh, Vinh Phuc) archaeologists have found sandstone moulds, melting furnaces and crucibles made of a mixture of clay and rice husks. Go Mun's pottery was of a solid kind, most common were post with broad, out turned rim and with decorations on the inside of mouth. Bronze tools are existed in greater numbers and were more favored than stone implements. The emergence of sickles marked a higher stage of agriculture.

Pre-Dong Son culture in the Ma and Chu River basin began from Con Chan Tien – Dong Khoi, Bai Man, Con Cau (lower layer) and Thieu Duong (layer 4). They have created chains; Con Chan Tien-Dong Khoi - Bai Man and the make up the first phase of the Bronze Age in the Ma and Chu River basin. The artifacts of this period shows similarities, such as decorated on pottery, an axes made from basalt stone, using jewelry as well as the production of stone tools of the Phung Nguyen culture. Quy Chu culture is prepared to be developed into the Dong Son culture, the cultural characteristic similarity is even more pronounced, where pottery is decorated inside the mouth. Stone artifacts still used, archaeologists have found many earrings, with ferrous or non-ferrous. These bronze objects found here have some similarities to the Red River Delta and the Lam River area, central of Vietnam. In early of Metal age, the majority residents moved down to a coastal plain to settle down. The traces of rice inprinted in pottery found at Bai Man, Dong Ngam and Thieu Duong. Many bone of buffalo, cow, pig, dog have been recovered at these sites, and statues of animals found in the ruins proved agricultural activities was developed.

2.2.3. Dong Son culture

The Dong Son culture named after the site in Thanh Hoa province where remarkable bronze drums were found, flourished about 3,000 years B.C.E. It corresponds to the late Metal Age, also call Iron Age which was directly developed from Pre-Dongsonian (Bronze Age) cultures that Vietnamese archaeologists have discovered (Ha Van Tan ed. 1999). Archaeologists found Dong Son artifacts in many places of Southeast Asia and China. In Vietnam, archetypal Dong Son artifacts have a wide distribution, but mostly concentrate along the Red, Ma and Ca River Deltas.

The Dong Son culture was not solely a bronze-working culture, people also worked and exchanged iron implements. Nevertheless, their bronze work, especially the production of ritual bronze kettledrums was of an exceptional quality. Bronze objects of the Dong Son culture had reached the peak of perfection in the art as well as technically, ex. the Dong Son bronze drum with

big size and beautiful decorated. Even with the small objects as fishhooks and personal ornaments also show extremely high aesthetic. Decorations on the drums illuminated perceptions and uses of the environment during this time. Illustrations depict the sun, herds of deer, aquatic birds, buffalo, and men robed in garments decorated with feathers of aquatic birds (Photo 4). Collection bronze weapon is worth noting because the diversity and richness.



Photo 4: Bronze drum (Lao Cai museum), photo by Nguyen Thi Mai Huong

The Dong Son inhabitant was also seafaring people who apparently traveled and trades throughout Southeast Asia (Fig.9).

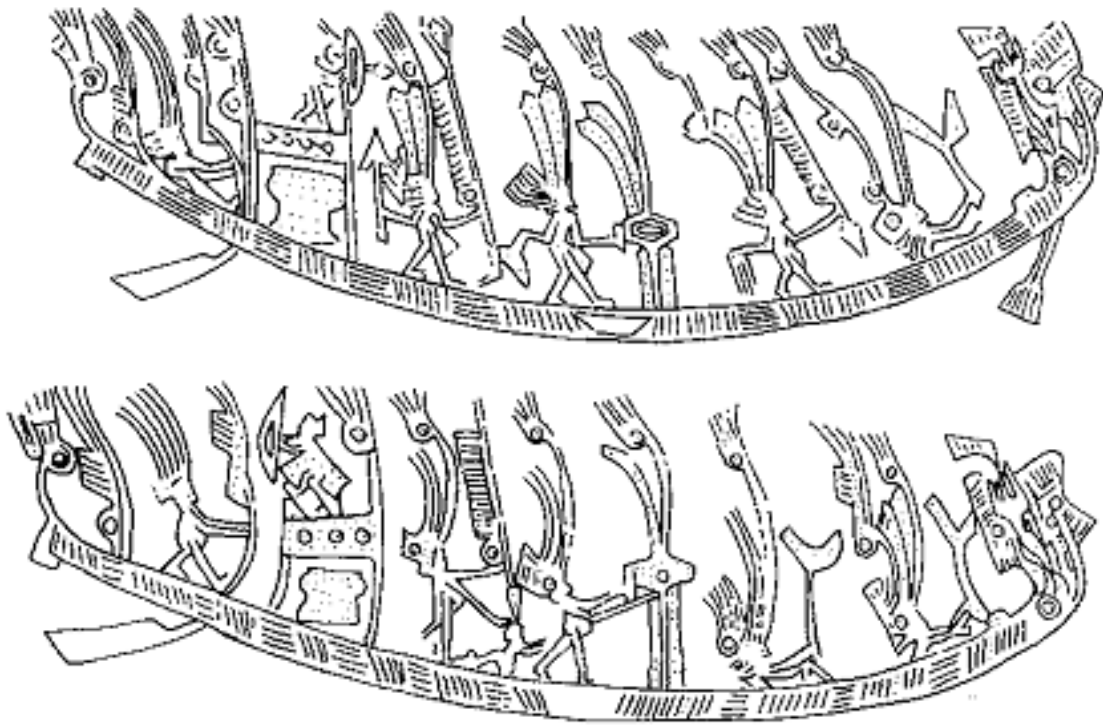


Fig. 9: Boat depicted on the shoulder of Ngoc Lu drum, Thanh Hoa province
(Dirk R. Spennemann, 1984)

Based on the artifacts have provided evidence of the continuous development of rice cultivation, including bronze plowshares (Photo 5), scythe and sickle blades. These kinds of tools were primarily used for argriculturale activites, cut down trees for building houses, ships, log coffins, and other items necessary for daily living. The nature and diversity of harvesting tool assemblage's fount at Dong Son culture sites suggest that agricultural activities were well developed by that time, and credited with originating the process of changing the Red River delta into a great rice growing region. Chu Van Tan has researched on harvesting tool assemblages, such as reaping hooks, knives, ploughs, and axes made of stone and metal. He had constructing a seriation table that shows the evolution of harvesting tools from Hoabinh to Dong Son times (Chu Van Tan 1979).



Photo 5: Bronze ploughshare from Dong Son site (Thanh Hoa Museum)

Besides bronze artifacts there are also appear iron artifacts with small amount. However, the presence of iron objects has been found (no less than 10 sites), and in some places traces of iron metallurgy were also discovered i.e. Vinh Quang site (Ha Son Binh). The major artifacts found are spades, hoes, sickles, spears, swords, arrows. The Dong Son people are also distinguished by their great stone monuments, it was built for religious functions.

Rather, the Dong Son period had offers one of the most powerful may not the only or earliest societies of Southeast Asian transforming themselves into more densely populated, hierarchical, and centralized communities. It can be said that the archaeological sites of Metal Age were distributed quite dense in the delta region. It may because of the topography of the Red River Delta



Photo 6: Buffalo image on bronze drum (Lao Cai Museum)

region is quite low and flat at that time and the hills interspersed are traces of ancient alluvium has very favorable conditions for settlement. These sites are distributed on diverse terrain form about 2m height, on natural dykes but mostly along the river, on the foothills of the high ground near water. Even in lowland area such as Ha Tay and Ha Nam, many boat coffins sites were discovered. Dong Son archaeological sites are also distributed on the ancient alluvial plain in Viet Tri, Lap Thach (Vinh Phu); Yen Phong, Yen Dung, Viet Yen, Hiep Hoa (Bac Giang), Tien Du, Tien Son (Bac Ninh).

Dong Son archaeological sites are often forming large clusters, such as: Co Loa relics (Dong Anh, Hanoi) include 6 sites were located between midland and plain in the Red River, Duong River and Ca Lo River basin. And Vinh Quang, Chua Gio and Go Chien Vay cluster were located in Thanh Tri, Thach That and Hoai Duc districts (Hanoi) (Fig.10) (Nishimura and Nishino 2003, Ha Van Tan ed. 1999: 210)

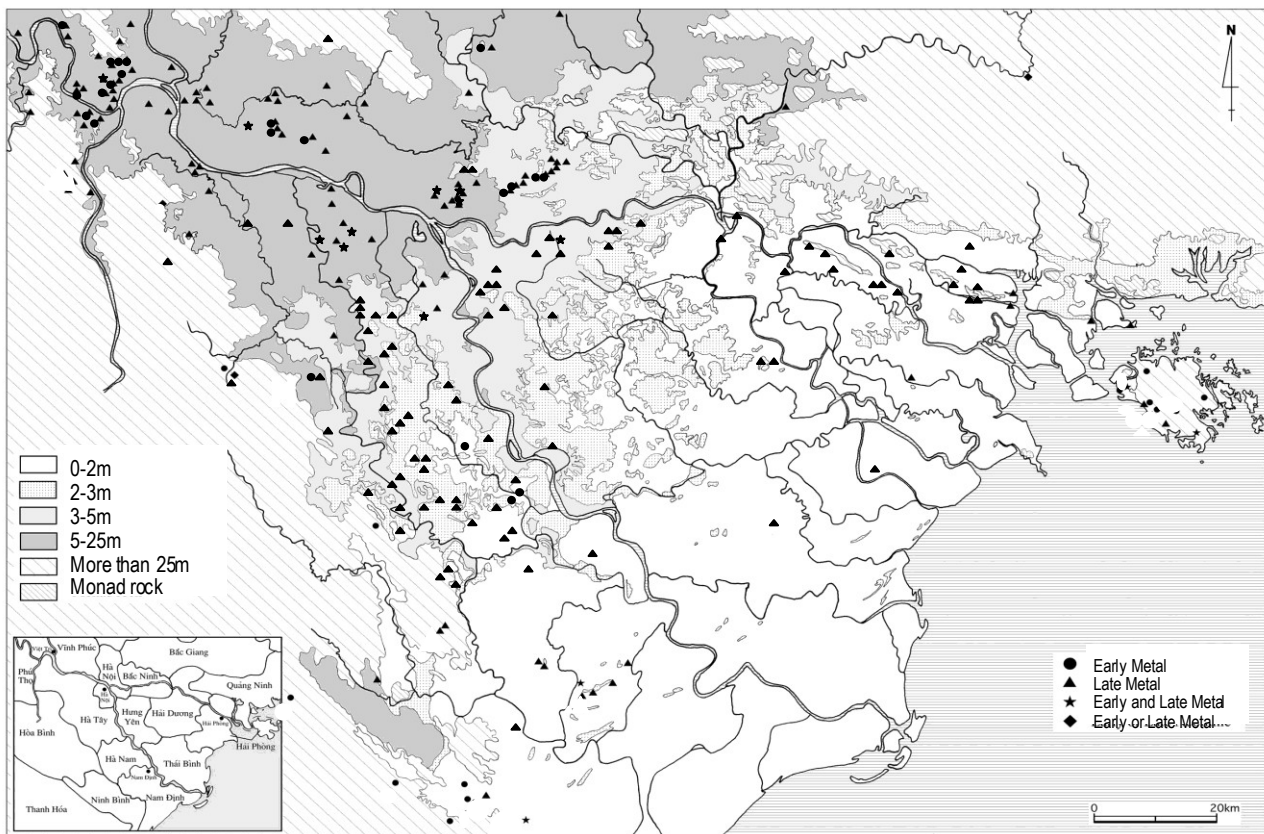


Fig 10: Distribution of Metal Age at Red River Delta (Nishimura and Nishino 2003)

In the Ma and Chu River basin, there are also existed some important clutters of the Dong Son archaeological site, such as: Dong Son, Dong Linh, Quy Chu, Thieu Duong, Dinh Cong. From

the center cultural in plain, Dong Son culture had spread gradually to the midland and mountainous area such as Thach Thanh, Vinh Loc, Tho Xuan, Ngoc Lac, Cam Thuy and also spread down to the coast in Hau Loc, Quang Xuong, Tinh Gia (Pham Minh Huyen 1996:42 - 43).

The Dong Son archaeological site clutters have formed several cultural - political - economic center and independence development. Those central have a relationship, contact and exchange with others. It can be recognized by the evidence of existence of the Dong Son drums. Each drum type corresponding to the conditions of its environment, according to Diep Dinh Hoa we can found in the Red River Delta specific drum type of mountains area such as Dao Thinh, midland like Lang Ca, as Duong Co and coastal type like Viet Khe; in the North central we have Dong Son (Thanh Hoa plain), Lang Vac (midland coastal Ha Tinh) (Pham Minh Huyen 1996:24-25).

The dating of pre-historical periods and relationship between elevations –archaeological distribution in Northern Vietnam during Holocene is brief in figure 11 (Nguyen Thi Mai Huong 2006).

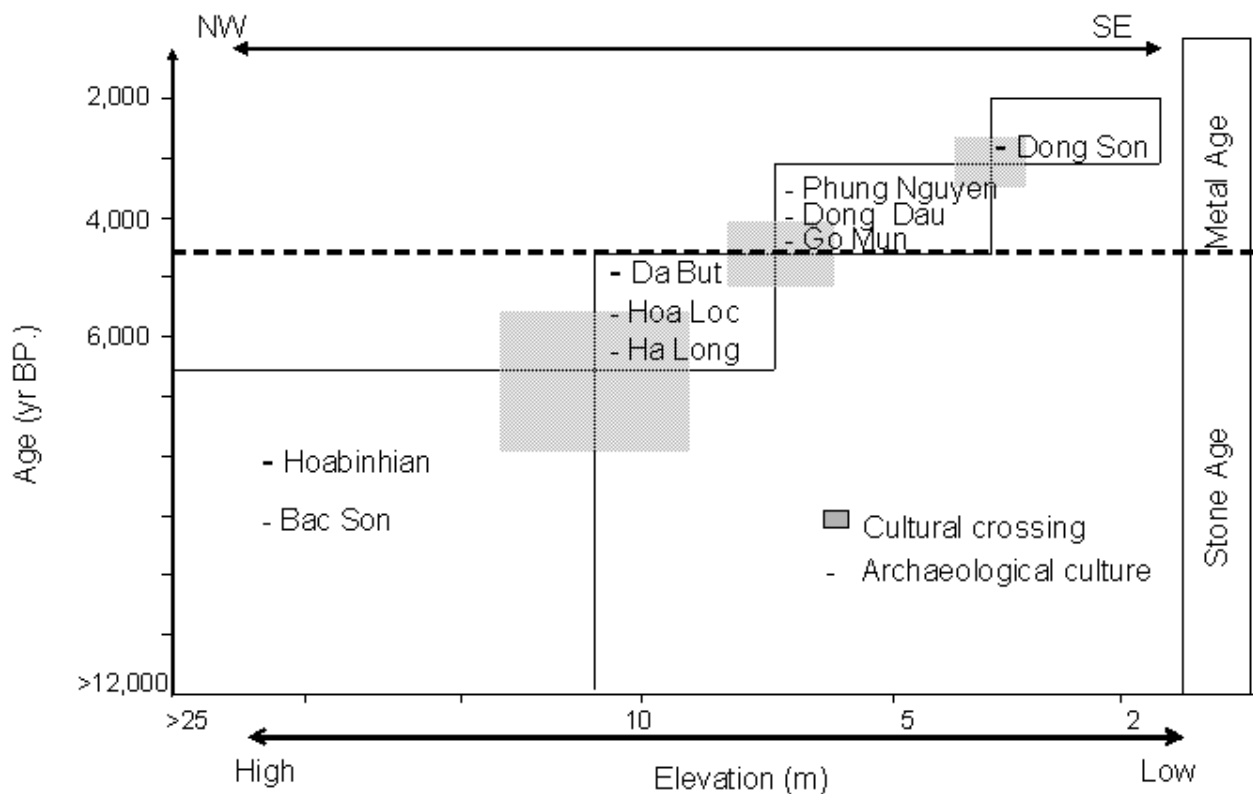


Fig 11: The sequential of Pre-history and relationship between elevations - archaeological distribution in Bac Bo Plain (Nguyen Thi Mai Huong 2006)

CHAPTER 3

RESEARCH METHODS

3.1. Field work

field works were conducted by the author, Prof. Tsuji Sei-ichiro, Prof. Vu Van Phai, the late Dr. Nishimura Masanari. They cooperated with some archaeologists of Vietnam Institute of Archaeology and Thanh Hoa provincial museums from 2007 to 2013 (Photo 7,8). Topographical map drawn in 1978 with scale 1:50.000 and the distribution map of the archaeological sites are used for their field works. The localities are shown in table 4 and figure 12.

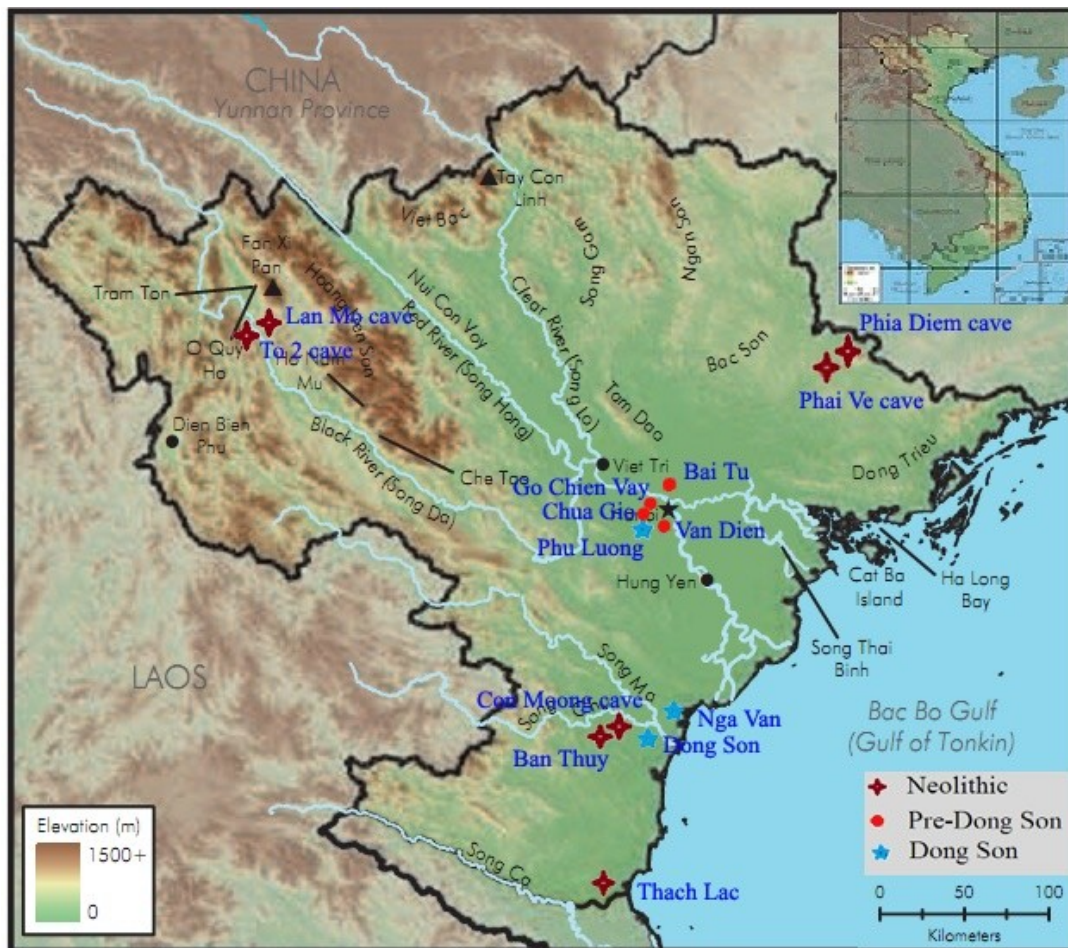


Fig. 12: Location of study sites

Study sites were chosen for pollen analysis because of the following reasons: 1- They are typical archaeological sites of the Neolithic, Pre-Dong Son, and Dong Son cultures; 2- Most of these sites are located in ideal area; 3- Most of these sites have radiocarbon ages for chronology. This is expected to enable us to reveal the pre-historical vegetation as a case study.

Table 4: Study sites and their locations

Core /site name	Location	Altitude (m asl.)	Depth (cm)	Environment
To 2 cave	21 ⁰ 40'08"N; 103 ⁰ 41'19"E	148	60	Karst limestone
Lan Mo cave	21 ⁰ 35'50"N; 103 ⁰ 57'11" E	115	70	Karst limestone
Phai Ve cave	Keo Pha Vil., Yen Trach Comm., Cao Loc Dist., Lang Son Prov.	About 15m above the surrounding		Karst limestone
Phia Diem cave	Vinh Trai ward., Lang Son city, Lang Son Prov.	About 12m -15m above the surrounding		Karst limestone
Con Moong cave	20 ⁰ 40'860"N; 105 ⁰ 65'164"E	147	360	Karst limestone
Ban Thuy	Doai Vil., Vinh Thinh Comm., Vinh Loc Dist., Thanh Hoa Prov.	Stand about 0,8-1,0m above rice field		Plain
Thach Lac	18 ⁰ 02'00"N; 105 ⁰ 57'25" E	1,9	160	Coastal
Van Dien	20 ⁰ 56'49"N; 105 ⁰ 49'28" E	4,5	180	Plain
Chua Gio	20 ⁰ 58'55"N; 105 ⁰ 41'11" E	Stand about 2m above rice field	180	Plain
Go Chien Vay	21 ⁰ 03'24"N; 105 ⁰ 43'44" E	8	180	Hillock
Bai Tu	21 ⁰ 07'55"N; 105 ⁰ 58'53" E	10	140	Hillock
Phu Luong	20 ⁰ 56'48"N; 105 ⁰ 45'56" E	4	140?	Plain
Nga Van	20 ⁰ 00'07"N; 105 ⁰ 56'54" E	3	140	Coastal
05DS	19°51'15"N; 105°46'58"E	5	210	River bank
07DS	19°52'1.70"N; 105°46'58.75"E	11	230	Hillock
09DS	19°50'53.78"N; 105°46'49.52"E	4	900	Plain
12DSK02	19°50'816"N;105°46'558"E	2,5	700	Plain



Photo 7 - 8: Survey and collecting sample by hand drilling core

3.2. Laboratory work

3.2.1. Sampling

Each sample was registered in the register book of laboratory with the laboratory number. The data such as lithologic type, geographic location, and collector's name were carefully described in the register book. All of these data as well as processing schedules are necessary details in order to keep good permanent records of each processed sample (Photos 9 and 10).

All subsamples were kept out of wind, extreme care in order to eliminate contamination and transposing of samples, cleaned equipment constantly, used filtered water in the complete process, and controlled the numbered beakers, plastic cups and the centrifuge tubes.



Photo 9 - 10: Sampling sample for pollen analysis is

77 samples were collected stratigraphically from the surface to 2,3m depth of the trench excavated in 2007 (07DS), 09DS core (9m depth) and 12DSK02 core (7m depth). These cores were taken at lowland of Dong Son site.

3.2.2. Pollen analysis and preparation

In the laboratory, about 5 cc plugs sediment were taken from the core. The surface of the cores was first scraped to remove contamination that may have occurred when the core taken in the field and after removed about 1cc sediment will use for analysis.

The subsamples were stored in labeled and close until processed. Samples were chemical processing according to standard methods introduced by Erdtman (Erdtman, 1960) and modified by Prof. Tsuji Sei-ichiro. Treatment involved using follow figure 13. Beside, sediment grain size were observed, and organic contents are also tested by loss on ignition method.

3.2.3. Microscopic analysis

Fossil pollen grains and spores were identified under the Carl Zeiss and the Olympus light microscopes. Fossil pollen grains were examined under light microscope using 20x, and 40x objectives and 10x eye piece for morphological observation, statistical counting, and taking photographs.

At least 200 palynomorphs were counted for each sample. The data was documented on a counting form. Some samples which were not rich pollen grains, more than one slide had to be prepared to obtain 200 pollen grains. If only a few pollen grains were present, they were identified and noted as present, without any calculation of the percentage. "Sp." refers to a situation where species designation is uncertain.

The single grain pollen preparation was used to deposit the type specimens and to take microphotographs. The photographs of the interesting pollen grains were taken under a light microscope using a 40x objective. During the photography, the hair needle was used to change to polar or equatorial views of the pollen grains. The LM photographs of modern pollen grains were taken using the same procedures as for fossil pollen grains.

The standard atlas of *Angiosperm Pollen Flora of Tropical and Subtropical South China* (IBSCIB-CAS 1982) was used for identification, with additional reference materials from Huang Tseng Chieng (1972), Faegri and Iversen (1989) were used as additional references and modern pollen samples at Vietnam Institute of Archaeology were also used.

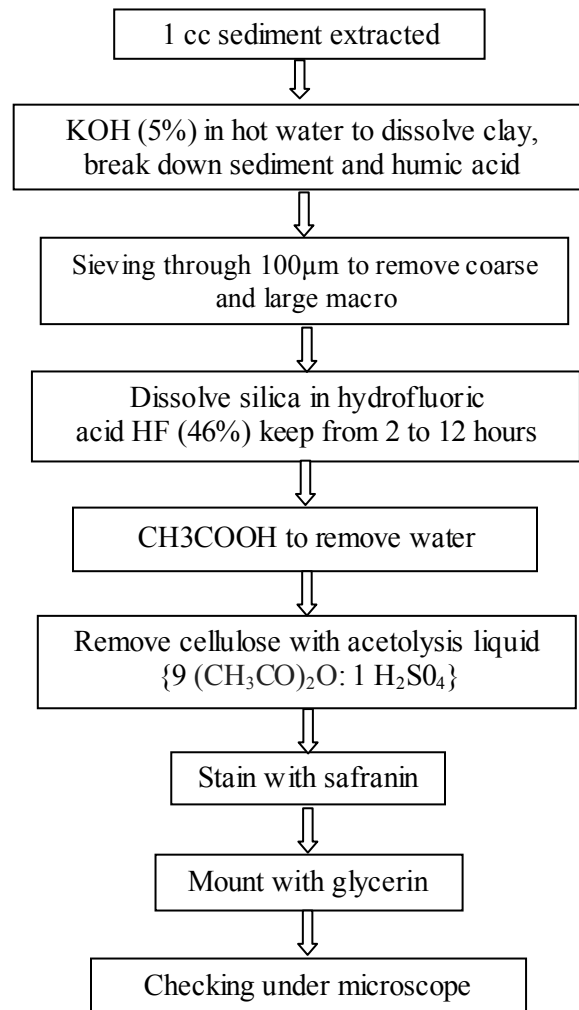


Fig. 13: Flowchart summarizing the pollen extraction methods used in this study

3.3. Paleoecological analysis.

For revealing and assessment of changes in regional plant communities only major pollen grains and spores taxa are included in the pollen diagram. Based on the presence and abundance of the indicator taxa which was calculated based on total pollen grains and spores. Fossil pollen grains and spores were put into some main groups, like fern spore (FS), arboreal pollen (AP) and non-arboreal pollen (NAP). In some previous works they are put into mangrove and non mangrove pollen groups.

The pollen grains were counted in each sample and presented in the form of pollen diagrams which is plot by the Tilia software introduced by Grimm E.C. (1992) version 1.7.16. Pollen diagram is displayed as the form: the vertical axis represents sedimentological, chronological, pollen zone,

and horizon axis of pollen abundance in each sample. The horizontal axis displays each pollen taxon percentage arranged in order of ecological groups.

To understanding and interpreted of tentative climatic and environmental changes, based on the component of pollen from the study, pollen were put into five or six categories introduce by Zhen Li (2006), such as: tropical arboreal, subtropical arboreal, temperate arboreal, herb, fern and mangrove. And information of other microfossil studies was used for the interpretation of the environment at the time of deposition.

3.4. Chronology

Five organic sediment samples of 09DS core at depths of 124cm, 181cm, 315cm, 515cm and 600cm were extracted for AMS dating. They are laid from layers containing significant changes in sediment features and pollen assemblages. Those samples analyzed at the Paleo-Laboratory (Paleo Labo Co., Ltd., Japan). And the other three more samples extracted from 262cm, 401cm and 563cm depth of 12DSK02 core were analyzed at the Arizona AMS Laboratory (USA). They are adding into part of pollen diagram and in table 13. All the radiocarbon dates are by AMS dating method.

Previous and others radiocarbon dates were analyzed by the Berlin Radiocarbon Dating Laboratory (Bln) and the Radiocarbon Dating Laboratory of the Vietnam Institute of Archaeology in Hanoi (HNK) (Pham and Nguyen 2000; Nguyen 2005; Nguyen 2009, Nakamura 2013). They are mostly radiocarbon fourteen dates and show on tables 5 and 13.

CHAPTER 4

RESULTS

4.1. Palynological study in Northern Vietnam

There are few research of vegetational history in this area. In the early 20th century, a French palaeo-botanist, Madeleine Colani, found fossil leaves of Fagaceae from the Tertiary deposits in Dong Giao (Ninh Binh) and Cua Rao (Nghe An) and remarked that some genera are same as live genera. Some identified taxa such as *Quercus incana*, *Betula alnoides*, *Liquidambar formosana*, *Phoebe pseudolanceolata*, *Celtis sinensis*, *Cinnamomum camphora* may be direct ancestors of living species or species themselves (Thai 1978).

Based on pollen analysis of the deposits dating from the Late Pleistocene to the Early Holocene at Phong Chau (Phu Tho province), Tran Dinh Nhan (1992) reported that the flora of the Early Holocene was a tropical - subtropical complex, in which tropical plants were more abundant. In this area, there were no marine and coastal plant remains. Pollen assemblages from Dong Dau site (Vinh Phuc Province) showed that fern spores existed in high percentage while arboreal pollen was rare, possibly due to human impact. Pollen grains of Convolvulaceae, Rutaceae, Chenopodiaceae, Amaranthaceae, Malvaceae and Poaceae indicate that vegetation in this site was dominated by herbs and shrubs trees (Tran and Dinh 1984; Nguyen 2002, 2003). In the Phung Nguyen 'cultural' layer of the Dong Dau site, archaeologists found quantities of burnt rice at the depths of 3.2 to 2.2m, as well as many floral vestiges such as Canariums, beans, pineapple seeds and bamboo sticks (Tran et al. 1970; Nguyen 1980).

Tran Quoc Vuong and Mai Dinh Yen (1994) examined the ecosystem from the Hoabinh culture to Dong Son culture, stating that "From the Hoabinhian and Bacsonian cultures to the Dongsonian culture, the Valley cultures developed to the Delta cultures. The Dongsonian sites are widely distributed from the mountainous and hilly areas to the seacoast, but they are mainly found in the delta. It means that the Dongsonians lived in various ecosystems".

Nguyen Duc Tung (1970) who studied the Trang Kenh site (Hai Phong) has reported that vegetation at Trang Kenh in the past was not much different from the present with the main pollen component being of Cucurbitaceae. He also found pollen grains of *Oryza sativa* and thought it a little bit smaller than *Oryza sativa* of China (Nguyen Duc Tung 1970). Pollen assemblages from the

Dinh Trang site (Ha Noi), Thanh Den site (Vinh Phuc) and Man Bac site (Ninh Binh) showed that tropical plants including many ferns were abundance and climate at that time was warm and wet (Nguyen and Pham 1998a, 1999 a,b). In Dai Trach site (Bac Ninh), pollen assemblages included many herbaceous plants such as Chenopodiaceae, Fabaceae, and dominant taxa of Poaceae (73%). Arboreal plants included tropical taxa and temperate taxa presented compose: *Taxodium* sp. was 52%, *Quercus* sp. was 11%, Palmeae was 21% and *Taxus* sp. Fern spores consist mainly of *Polypodium* sp. was 66% and *Gleichenia* sp. at the base of this site to indicated that more humid than upper part. In addition, we also found some pieces of *foraminifera* at the lower part, it can be suggested that this area was a lagoon at that time and effected by sea-water (Nguyen and Dinh, 2002).

Research by Pham Van Hai et al. (2004) has shown that pollen assemblages in Bac Bo Plain can be divided into two. Fourteen radiocarbon dates from the assemblage I ranged from 9,635±60yr BP to 4,561±46yr BP, while those of the assemblage II ranged between 6,620±40yr BP and 505±50yr BP. High percentages of fern spores in both assemblages indicated warm and humid climatic conditions. They also found pollen grains of broad leaves, whose species are well adapted to warm and humid condition. Fagaceae (*Quercus*, *Castanea*, *Castanopsis*, *Lithocarpus*), Magnoliaceae (*Magnolia*, *Michelia*), Juglandaceae (*Carya*, *Platycarya*, *Pterocarya*, *Juglans*), a few pollen of *Betula* or *Alnus* was found in this area. Mangrove pollen grains occurred in both assemblage but the assemblage of each was not same. For example, in assemblage I (9,635±60yr BP to 4,561±46yr BP), Rhizophoraceae was dominant (being a special plant for mangrove forests in the development stage) whereas Sonneratiaceae were dominant in assemblage II (6,620±40yr BP to 505±50yr BP) which is characteristic of the degradation stage.

Related to the transformation of sea levels from late Pleistocene to Holocene in the Red River Delta, Vu Quang Lan (2004) showed that in late Pleistocene deposits, mangrove pollen grains was scattered from the Luoc River to the present sea. The mangrove plants were not very abundant and was usually poor, often included *Hibiscus*, *Sonneratia*, and *Acanthus*. In the early and middle Holocene, the mangrove pollen grains were abundant in quantity as well as in genus and species composition. In the late Holocene, the mangrove pollen was reduced gradually and nearly became extinct, indicating a regression process and the formation of the delta with natural vegetation as seen today.

Recently, pollen analysis in Vietnam has been strengthening. Sediment from archaeological sites from Neolithic to historic time has been collected for this purpose. The results somewhat making more clear picture of vegetation and human activity in Northern Vietnam in Holocene.

4.1.1. The pollen analysis of Neolithic sites in North Vietnam

Neolithic in Vietnam exists in across from Pleistocene to Holocene, dated about 12,000 BP to 4,000 BP. Directly followed the Hoabinhian culture which is well known, not only in Vietnam, but also throughout Southeast Asia, for its distinctive diverse of lithic tools. Sea level changes had a strong impacted on the distribution of the Neolithic archaeological sites in North Vietnam (Fig.6, 7). At the early Neolithic, the sites were mostly distributed in a wide range of terrains in the mountainous area, which about or higher than 25 m above sea level (Fig.8). In the late Neolithic period, it can be found at the plain and coastal area, but especially within the floral bioregions adapted to a tropical and humid climate pattern. The cultural achievements of the Hoabinhian and post Hoa Binh cultures established favorable prerequisites for the formation and development of subsequent Neolithic archaeological cultures.



Fig. 14: Location of 7 Neolithic sites (Nguyen Thi Mai Huong 2013)

Few Neolithic sites have been study on pollen, and therefore the vegetation of Neolithic period is not discussed yet. Because of that reason, sediment of 7 Neolithic sites (Fig 15, Tab.4) has been collected for pollen analysis purpose (Nguyen and Pham 2008, Nguyen 2013). They are mostly distributed in mountainous area and in the cave site, except Ban Thuy and Thach Lac sites are located in plain and costal area which about 1-2m above sea level.

4.1.1.1. To 2 cave

To 2 cave (Chieng Bang commune, Quynh Nhai district, Son La province) is located at the foot of Lan Danh mountain near the Da River, coordinate $21^{\circ}40'08''\text{N}$; $103^{\circ}41'19''\text{E}$ (Fig.15; Tab.4). During the excavation of the Institute of Archaeology in 2008, 10 soil samples were collected from the west wall, in the intervals of 5 cm each, as well as 10 samples from two burials (Burial No.3 and No.8). Results indicate that herbaceous pollen grains accounts for 49 percent, arboreal pollen grains 4 percent, gymnosperm pollen grains 4 percent, shrub pollen grains 4 percent and fern spores 39 percent (Fig.16).

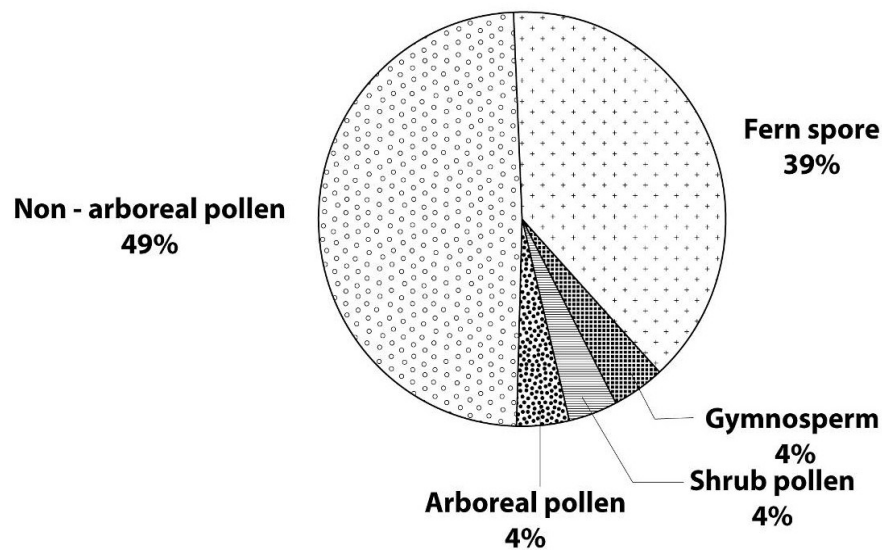


Fig.15: Pollen and spore components from To 2 cave stratigraphy (Nguyen Thi Mai Huong, 2013)

The composition of fern spores is very diverse and consistent from the bottom to the surface, mainly of *Polypodium* sp., *Cyathea* sp., *Lygodium* sp., and *Microlepia* sp. There is a difference in species composition and number of pollen grains recovered between the cultural layers and the grave (Fig.16). Non arboreal pollen collected from the cultural layer contains 77 percent including mainly of Poaceae, *Chenopodium* sp., and Compositae; the shrub species existed Rubiaceae and *Morus* sp.;

and the arboreal presented species *Hamamelis* sp., *Alnus* sp., *Magnolia* sp., and *Michelia* sp. Based on the combination of varieties obtained, and the taxonomic identification possible to the level of the family, it can be seen that these plants were adapted to the hot and humid climatic conditions of tropical rainfall (Nguyen et al. 2009b).

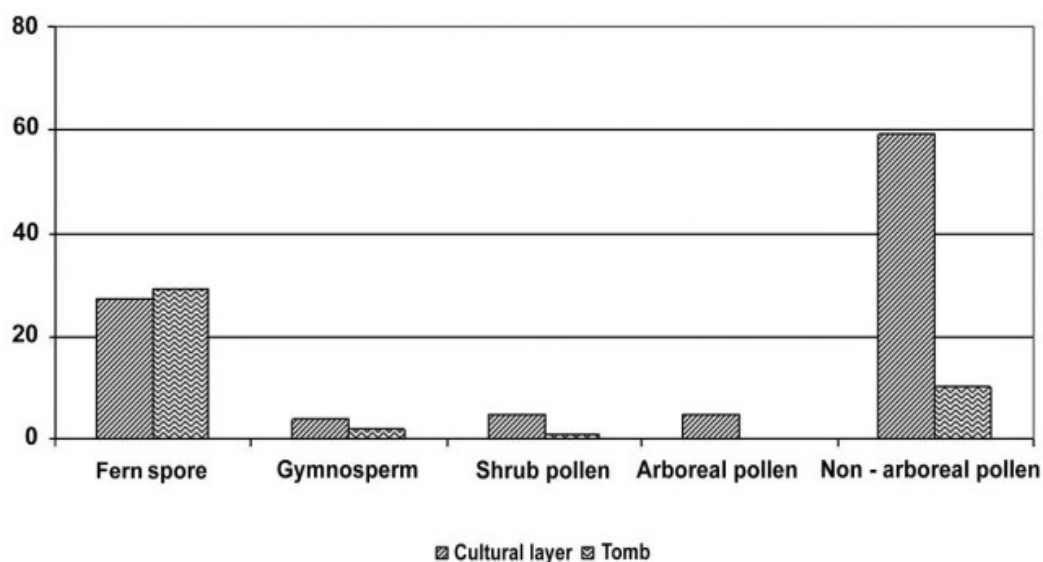


Fig. 16: Pollen and spore from the cultural layers and burial of To 2 cave (Nguyen Thi Mai Huong, 2013).

4.1.1.2. Lan Mo cave

Lan Mo cave (La Muong hamlet, Muong Trai commune, Muong La district, Son La province) (Fig.14; Tab.4) coordinate $21^{\circ}35'50''\text{N}$; $103^{\circ}57'11''\text{E}$, exposes a well preserved stratigraphy with thick cultural layers. During the excavation in 2008, 13 soil samples were collected from the unit B10 (dark brown and dry soil), and 3 samples from the unit H7 (dry brownish-yellow soil). They were extracted at an interval of 5 cm, for pollen analysis and the study of flora and environment of the region. The results show that non-arboreal pollen (32 percent) and ferns (43 percent) are prevalent (see Fig. 17).

Pollen taxa mainly consist of non-arboreal plants (*Chenopodium* sp., Compositae, Poaceae, Leguminosae, Liliaceae), shrubs (*Morus* sp., *Sapindus* sp.), and ferns (*Lygodium* sp., *Cyathea* sp., *Microlepia* sp., *Coniogramme* sp., *Polypodium* sp., and Polypodiaceae). Arboreal plants include *Liquidambar* sp., *Castanopsis* sp., and *Quercus* sp. In general, pollen and spore components from Lan Mo are prefer hot and humid tropical climates (Nguyen et al. 2009a). The counts of pollen collected

from the stratum in H7 are less than that from B10. This phenomenon may be due to the poorer condition of the H7 samples, or the dryness, or oxidation of the sediment.

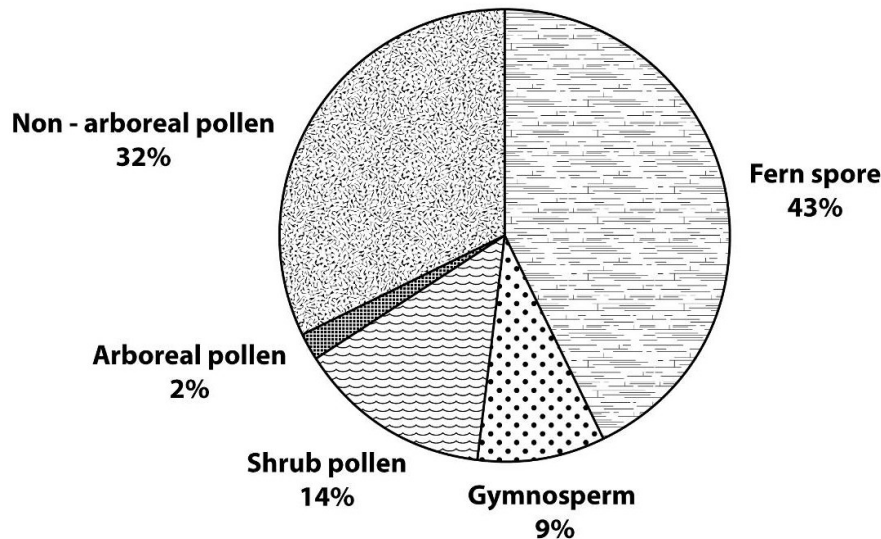


Fig. 17: Pollen and spore components from Lan Mo cave stratigraphy (Nguyen Thi Mai Huong, 2013).

4.1.1.3. Phai Ve II cave

Phai Ve cave (Lang Son city, Lang Son province) (Fig.14, Tab.4) is a settlement site located on the Phai Ve Mountain which is near to the Ky Cung River. This cave is about 15m above the surrounding. In 1906, H. Mansuy explored this site and found some fossil of animal bones, which is dated to late Pleistocene. In the 1960s, Vietnamese archaeologist investigated this cave again but there was no report. In 1998, Institute of Archaeology in collaboration with Lang Son Provincial Museum conducted excavation this site. The artifact assemblage found from the site has been identified as most likely belonging to the Mai Pha culture (Ha 1998; Ha ed. 1998). Six soil samples were collected from profile of the excavation trench for pollen analysis. The pollen analysis results show low concentration of gymnosperm such as, *Pinus* sp., *Taxodiaceae*, *Metasequoia* sp. like; Arboreal with *Liquidambar* sp., *Rubiaceae*; non-arboreal pollen including *Poaceae*, *Compositae*, *Chenopodiaceae* and fern spores remained of *Lycopodium* sp., *Conniogramma* sp. Those plants are kinds of sub tropical and temperature plants (Nguyen and Pham 1998b).

4.1.1.4. Phia Diem cave

Phia Diem cave (Lang Son city, Lang Son province) (Fig.14, Tab.4) is settlement site located on Phia Diem Mountain, about 3 km to Ky Cung River. In front of the cave, there is a valley which is good for paddy rice cultivation. This site was discovered in early 1998, and excavated in

September 1998, by the Institute of Archaeology. Based on the artifact collections found at the site, Vietnamese archaeologists have identified them as most likely belonging to the Mai Pha culture, late Neolithic (Ha 1998; Nguyen et al. 1998). Seven soil samples were extracted from the excavation strata for pollen analysis. The pollen analysis results from Phia Diem cave show low concentrations and similar to vegetation of Phai Ve II cave. The pollen of gymnosperm is mainly consists of *Pinus* sp.; Arboreal with *Liquidambar* sp., Magnoliaceae, *Magnolia* sp., Rubiaceae; non-arboreal pollen include Poaceae, Chenopodiaceae and fern spores remain of *Lycopodium* sp., *Conniogramma* sp. These plants are kinds of subtropical and temperature plants (Nguyen et al. 1998).

4.1.1.5. Con Moong cave

Con Moong site is located in the limestone ranges of Mo hamlet, Thanh Yen commune, Thach Thanh district, Thanh Hoa province, coordinate 20°40'860"N; 105°65'164"E (Fig.14; Tab.4). This is very big cave that located near to a stream and looked into a valley, which was a good place for settlement. This site was first excavated in 1976. The cultural layer of this site, which is the same as other Hoabinhian sites contained dense of land snails, freshwater snails, and burnt traces in some places. The artifacts found from excavation contribute to the clarification of the archaeological issues concerning the relationship between pre-Hoabinhian, Hoabinhian, and post Hoabinhian cultures, between the Paleolithic and Neolithic, and between the Pleistocene and the Holocene (Nguyen Khac Su 1977).

In 2008, the site was continued to be studied, the stratigraphy of excavation in 1976 was reexamined and eighteen soil samples were collected for pollen analysis (Nguyen and Pham 2009). The stratigraphic sequence for Con Moong cave is based on the change of sediment color, the occurrence of pollen and spores in these sediments, and the lithic artifacts associated with the distinct cultural layers in the cave (Fig.18). The results of the pollen analysis for the 18 samples are shown in figure 20. It can be observed that herb pollen predominates (38 percent), followed by arboreal pollen (25 percent).

Among these, fern spores mainly consist of *Microlepidia* sp., *Polypodium* sp., Polypodiaceae gen. indet., *Lycopodium* sp., *Cyathea* sp., *Selaginella* sp. and *Coniogramme* sp.. Gymnosperms pollen belongs to *Cycas* sp., shrub pollen consists of Rhamnaceae, Rubiaceae, Ericaceae, *Morus* sp., *Euphorbia* sp., and *Carya* sp., and arboreal pollen includes *Castanea* sp., *Castanopsis* sp., *Ilex* sp., *Rhus* sp., *Betula* sp., *Myrica* sp., *Juglans* sp., *Melia* sp., *Engelhardtia* sp., *Platycarya* sp. and *Ulmus* sp. Finally, herb pollen includes species such as Compositae, Liliaceae, Poaceae, *Chenopodium* sp., Leguminosae, and Labiatae (Nguyen and Pham 2009; Nguyen Thi Mai Huong 2013).

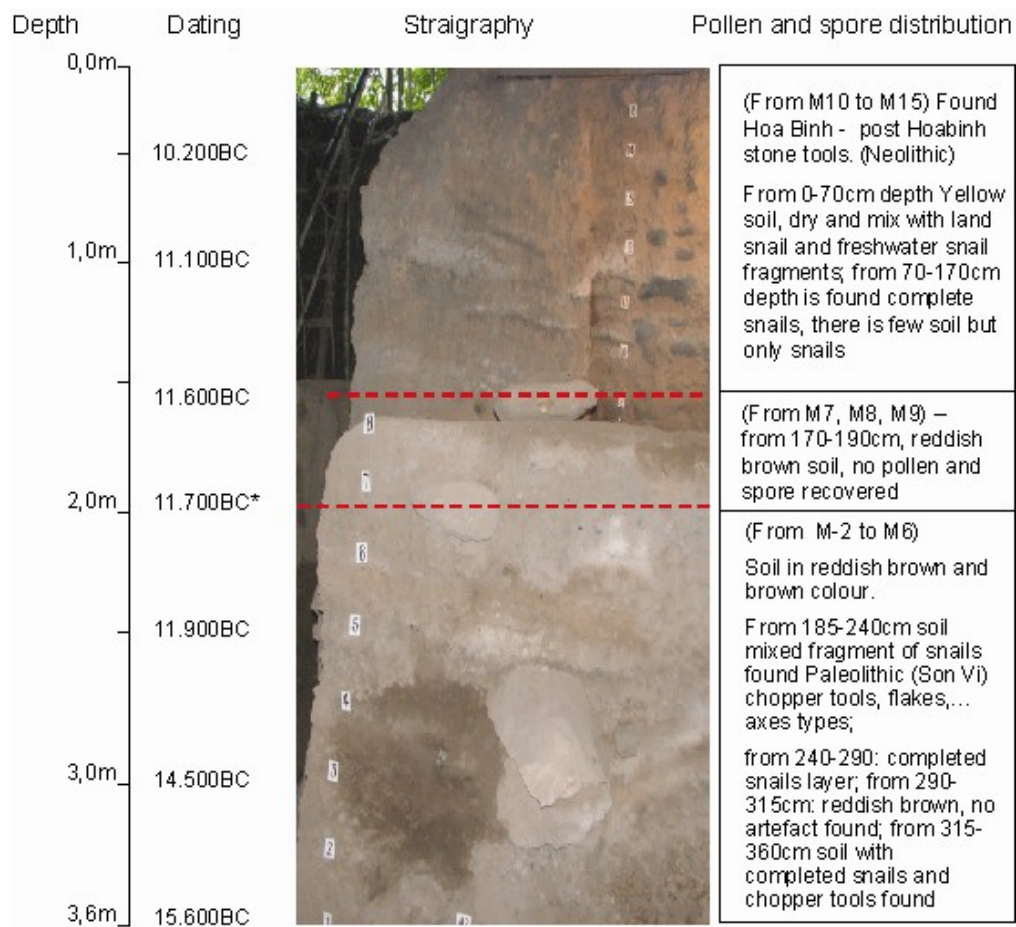


Fig. 18: Con Moong Cave stratigraphy, showing the location of the extracted samples (Nguyen Thi Mai Huong, 2013)

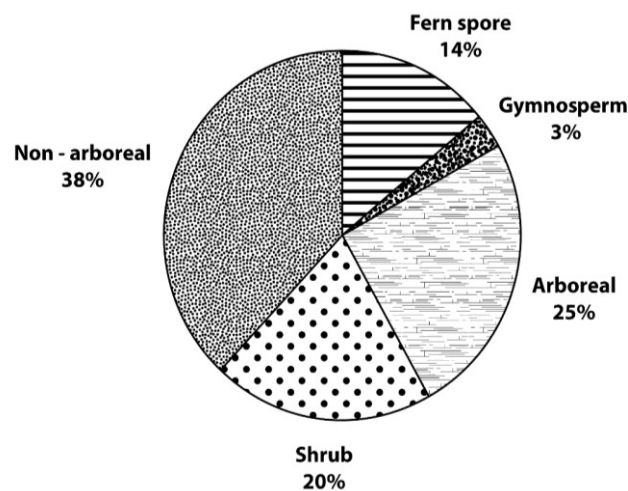


Fig. 19: Pollen and spore components of Con Moong cave soil samples (Nguyen Thi Mai Huong, 2013).

In general, the pollen and spores recovered from the Con Moong site are from terrestrial plants adapted to fresh water and humid conditions. This interpretation is consistent with the identification of snails (Dang 1977) and other faunal remains (Vu The Long 1977). The pollen of some species, like *Castanea* sp., *Castanopsis* sp., *Betula* sp., and *Juglans* sp. indicates that plants growing on high elevations are more adapted to humid and cool temperatures. Among these, species diversity of herb pollen, shrub and arboreal plants is high, while very little pollen from gymnosperm species, and fern spores were found. This information provides a rich image of the landscape surrounding Con Moong cave at that time.

A comparison of the plant component present in the two cultural layers (see Fig. 20) shows slight differences between the early Hoabinhian and post Hoabinhian cultural levels at Con Moong. During the early Hoabinhian period, arboreal pollen is abundant, while fern spores are abundant within the post Hoabinhian strata. However, herb pollen concentrations are the same for both layers. The reduced arboreal and shrub pollen during the late Hoabinhian period might be related to clearance activities conducted by prehistoric human populations of the area, which is supported by the polished axes found on site (Pham et al. 1990).

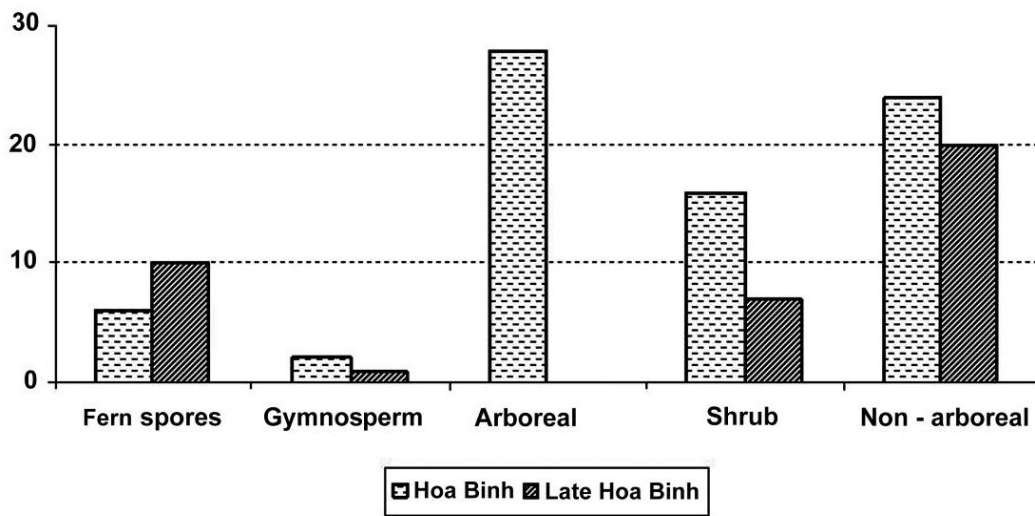


Fig. 20: Comparison of the distribution of pollen and spore between the two cultural layers at Con Moong cave (Nguyen Thi Mai Huong, 2013)

The date sequence in accordance to the stratigraphic depth shows that the stratigraphy at Con Moong cave is intact (Nguyen Khac Su, 2009). A C^{14} date from snail shell, found at 3.5 m depth in Con Moong Cave, was dated to $12,920 \pm 90$ BP (Bln. 3496/I) and at 3.6m dated $13,980 \pm 200$ BP (HNK-491). The stratigraphic sequence at 2.4-2.0 m depth is dated by another snail sample to c.

11,830±79 BP (Bln.3488), at 2.5m dated to c. 11,240±205 BP (NHK-493) (Tab. 5). At this depth, pollen of Chenopodiaceae, Leguminosae, *Melia* sp., *Quercus* sp., and *Myrica* sp. was recovered. Although this pollen is not representative of the entire floral ecosystem of that time, it demonstrates that arboreal pollen was abundant and consistent at this site, which is a characteristic of a tropical ecosystem. In addition, some fragments of *Canarium* sp. and *Thea* sp. seeds were also identified (Hoang and Nguyen 1977).

4.1.1.6. Ban Thuy site

Ban Thuy site (Vinh Loc district, Thanh Hoa province) (Fig. 14; Tab.4) was first discovered in 1978 and test excavated in 2001 by the Institute of Archaeology. This site located in the low valley of about 0,8m to 1,0m above rice field, on the right side of Ma River. The site is covered of about 200m². Some part of this site is destroyed because of making road, houses or cultivation. The stratigraphy is composed of numerous fresh snails and bivalves fragments. Six soil samples from two test excavation trenches were collected for pollen and spores analysis. Based upon stone tools and pottery typologies, Bui Vinh stated that the site belongs to Da But culture, which is dated to 5000±95BP (HNK-89) and 5560±95BP (HNK-90) (Tab.5) (Bui 1991; 2001). The results from Ban Thuy show a high concentration of fern spores. This suggests that the area had high humidity during prehistoric times, with predominant of shrubs, small trees and grass species. At 0.50 m depth, there are rich concentrations of spores and pollen. At 0.80 m depth, the diversity of pollen and spore declines, but Poaceae pollen was remains in high percentage (84 percent) possibly including paddy rice species (Nguyen and Pham, 2003; Nguyen Thi Mai Huong, 2013)

4.1.1.7. Thach Lac site

Thach Lac site is located at 18°02'00"N; 105°57'25"E in Thach Lac village (Thanh Ha district, Ha Tinh province); It is a shell midden site that is about 1,9m above sea level (Fig. 14; Tab.4). The site was investigated in 1962 and excavated in 1963 by Archaeological team and Ha Tinh Culture Bureau (Nguyen and Ha 1963). In 2002, the Vietnam National History Museum, Ha Tinh Provincial Museum in cooperation with the Academia Sinica, Taiwan conducted excavations. Nine soil samples were collected from the stratigraphic profile for pollen analysis. This is the only Neolithic site (Tab.5) along the northern central coast of Vietnam where pollen analytical research had been conducted. The stratigraphic sequence from the Thach Lac site contains of thick cultural layers, with high concentration of marine mollusks, mostly bivalves at the depths of 60-80 cm and 120-145 cm, but no pollen or spores were recovered. This

is probably due to the stratigraphy that is composed of numerous shell fragments, giving it a loose structure in which pollen could be easily washed away.

Samples from the depth of 10-60 cm contained predominantly herb pollen, but at 90-120 cm depth, arboreal pollen is dominates again. Thus, large trees primarily represent as the dominant plant species within the floral ecosystem at 90-120 cm depth. Fern spores of Polypodiaceae were found in a large quantity, which also indicates an area with relatively high humidity. Mangrove pollen was also found, and thus it can be said that the environment of this area was certainly marine influenced. Further geological research will be needed for further definite conclusions about sea level fluctuations and their effects on the landscape and environment of Ha Tinh province, and especially the area immediately surrounding this archaeological site (Nguyen et al. 2003; Nguyen Thi Mai Huong, 2013).

Concluding remarks

Results from samples of 7 Neolithic archaeological sites shown comparatively low concentrations of pollen and spore overall. There is no reason why pollen should not preserved in other tropical caves, for example Maloney has been recovered pollen and phytolith from Gunung Mulu cave, and three other caves at Sarawak (Indonesia) but unrecovered from other caves sites (Maloney 1994). It seems assumed because of the high humidity condition in the limestone caves in North Vietnam.

To reconstruct the vegetation and understand more about the ecology, the results from the palynological analyses were classified into five groups after Li Zhen (2006a,b) (see Tab.6): Tropical plants are characterized by Magnoliaceae (*Magnolia* sp.), Moraceae (*Morus* sp.), Sapindaceae (*Sapindus* sp.) and Rubiaceae; while sub-tropical plants consist mainly of Fagaceae (*Castanopsis* sp.) and Hamamelidaceae (*Liquidambar* sp., *Hamamelis* sp.). Temperate plants include Pinaceae (*Pinus* sp.), Fagaceae (*Quercus* sp., *Castanea* sp.), Juglandaceae (*Juglans* sp.), Ulmaceae (*Ulmus* sp.), Aquifoliaceae (*Ilex* sp.) and herbs presented such as Compositae, Chenopodiaceae, Malvaceae, Leguminosae, Cyperaceae and Poaceae species. Fern spore is a primary species of the Pteridophyta family (*Lygodium* sp., *Polypodium* sp., *Microlepia* sp., *Stenochlaena* sp., *Cyathea* sp., *Acrostichum* sp.).

The pollen recorded from these sites, such as: Poaceae, Malvaceae, Palmae, *Morus* sp. may relate to the plants that believed to have been taken cultivation in Southeast Asia (Maloney 1994). Based on this analysis, it is argued that the vegetation during the Neolithic period in northern

Vietnam reflects both natural and cultural influences on the environment, possibly as a mosaic of grassland species, shrub trees and native forest.

Table 5: 14C radiocarbon dates of the Neolithic sites

N	Site name	Signed	Depth (cm)	Material	Analysis Lab.	Dating (yr BP)
1	Ban Thuy	BT01	100	Corbicula	HNK-90	5,560±95
2	Ban Thuy	BT01	40	Corbicula	HNK-89	5,000±95
3	Con Moong cave	CM 86-A 2	40-60	Charcoal	Bln. 3482	8,500±60
4	Con Moong cave	CM 86 - A 3	60-80	Charcoal	Bln. 3483	9,150±60
5	Con Moong cave	CM 86 A 4b	120-140	Charcoal	Bln. 3484	9,380±60
6	Con Moong cave	CM 86 - B 3aM 1	200-240	Snail	Bln. 3488	11,830±70
7	Con Moong cave	CM 86 - B 3aM 2	240-260	Snail	Bln. 3494	12,040±70
8	Con Moong cave	CM 86 - B 4aM 2	280-300	Snail	Bln. 3495	12,150±70
9	Con Moong cave	CM 86 - B 5	350	Snail	Bln. 3496/I	12,920±90
10	Con Moong cave	08CM M 15	50	Snail	HNK- 496	9,840±175
11	Con Moong cave	08CM M 11	100	Snail	HNK-495	10,660±145
12	Con Moong cave	08CM M 8	160	Snail	HNK-494	10,990±210
13	Con Moong cave	08CM M 5	250	Snail	HNK-493	11,240±205
14	Con Moong cave	08CM M 3	300	Snail	HNK-492	13,110±180
15	Con Moong cave	08CM M 1	360	Snail	HNK-491	13,980±200
16	Phia Diem cave					4700-5000BP*
17	Phai Ve II cave					4700-5000BP*
18	To 2 cave					? – 3000BP**
19	Lan Mo cave					5000-3000BP**
20	Thach Lac					4000-3500BP***

(Source: Nguyen 2005; Pham and Nguyen 2000; Nguyen 2009; Nguyen et al. 2012**, Nguyen et al. 1998*, Ha et al. 1998*, Ha ed. 1998*** (* because there are no radiocarbon dating, the age is estimate based on archaeological chronology was used). Bln: Berlin Radiocarbon Dating Lab; HNK: Radiocarbon Dating Lab., Institute of Archaeology Vietnam in Hanoi).

Table 6: List of plant taxa recovered from 7 Neolithic sites.

Tropical arboreal plants	Sub-tropical arboreal plants	Temperate arboreal plants	Herbs	Fern spores
<i>Aralia</i> sp.	<i>Castanopsis</i> sp.	<i>Alnus</i> sp.	<i>Chenopodium</i> sp.	Polypodiaceae
<i>Morus</i> sp.	<i>Liquidambar</i>	<i>Castanea</i> sp.	Chenopodiaceae	<i>Lygodium</i> sp.
<i>Carya</i> sp.	sp.	<i>Ilex</i> sp.	Compositae	<i>Coniogramme</i>
<i>Melia</i> sp.	<i>Hamamelis</i> sp.	<i>Ulmus</i> sp.	<i>Polygonum</i> sp.	sp.
<i>Sapindus</i> sp.		<i>Myrica</i> sp.	Liliaceae	<i>Microlepia</i> sp.
Palmae		<i>Sequoia</i> sp.	Leguminosae	<i>Cibotium</i> sp.
Rubiaceae		Taxodiaceae	Labiatae	<i>Coniopteris</i> sp.
<i>Platycarya</i> sp.		<i>Quercus</i> sp.	<i>Digitaria</i> sp.	<i>Dicksonia</i> sp.
Ericaceae		<i>Betula</i> sp.	<i>Flagellaria</i> sp.	<i>Selaginella</i> sp.
Rhamnaceae		<i>Juglans</i> sp.	Malvaceae	<i>Osmunda</i> sp.
<i>Euphorbia</i> sp.		<i>Metasequoia</i> sp.	Poaceae	<i>Lycopodium</i> sp.
<i>Rhus</i> sp.		<i>Pinus</i> sp.	<i>Cyperus</i> sp.	<i>Pteris</i> sp.
<i>Magnolia</i> sp.		<i>Engelhardtia</i> sp.	<i>Pilea</i> sp.	<i>Gleichenia</i> sp.
<i>Pterocarya</i> sp.				<i>Cyathea</i> sp.
Magnoliaceae				<i>Polypodium</i> sp.
				<i>Salvinia</i> sp.
				<i>Acrostichum</i> sp.

(Nguyen Thi Mai Huong, 2013)

4.1.2. The pollen analysis of Pre-Dong Son culture

The Phung Nguyen culture started from about 4,000 to 1,700yr BP which was developed from the late of Neolithic. Phung Nguyen culture is consider to the early stage of the Bronze Age in Vietnam which is including three continue development stage, they are Phung Nguyen – Dong Dau – Go Mun and it so call Pre-Dong Son period. This period was remarked an important in prehistory time because of bronze objects appeared in ancient people life. This time was apparently contemporaneous with the expansion of human settlement in Bac Bo Plain (Ha ed., 1999). Settlement sites of Bronze Age are mainly located at lower Pleistocene terrace and Holocene terrace (5 to 20m above sea level), at flood plain, natural levee (5 to 10m above sea level), sand ridge (2 to 3m above sea level), at wave-cut bench and sand dune along the coast (Fig. 10).



Fig.21. Location of Pre-Dong Son sites have been analysis in this study

Archaeologist have been determined that the cultural layer of many Pre-Dong Son archaeological sites showed long-lived settlements, for example, cultural layer of Dong Dau and Dinh Trang sites include four continue stages: Phung Nguyen- Dong Dau- Go Mun and Dong Son; Dai Trach site is typical Dong Dau culture with Go Mun factor in the upper part.

In this study, sediment from some Pre Dong Son archaeological sites has been collected for pollen analysis, the location of these sites show on figure 21. Those sites are distributions on late Pleistocene and Holocene terrace near Hanoi city which is stand about +2 to +10m above sea level (Tab. 4). The cultural layer of those sites remains the traces of three typical stage of Bronze Age (Phung Nguyen – Dong Dau – Go Mun) in North Vietnam. Pollen analysis and sediment grain size, results are described below:

4.1.2.1. Van Dien core

Van Dien site is located at Thanh Tri District, Ha Noi City (altitude +4-5m, 20°56'49"N; 105°49'28"E). The core site is about 5km east of Red River (Fig.21, Tab.4), and covers about 175.000 square meters. The site was first discovered and studied in 1962. Archaeologists has been found that artifacts of this site belong to late Neolithic-early Metal (Phung Nguyen culture) dated around 4,000 years ago, they are mainly of stone adzes, and rectangular axes (Hoang and Nguyen, 1962).

From 180cm length of boring core collected from Van Dien site (Photo 11). According to the lithology of the core 19 samples were extracted for pollen analysis and 18 samples for particle size examination. Results of pollen analysis are shown in table 6 and component of particles size is show in figure 23 (Nguyen Thi Mai Huong 2006; Nguyen et al. 2007).

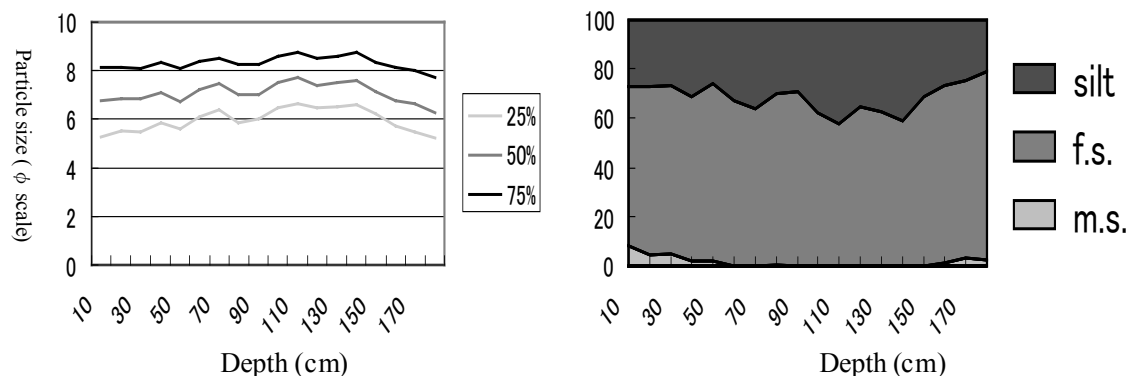


Fig. 22: Accumulative percentage of Van Dien core



Photo 11: Van Dien's core sediment in descending order

The pollen analysis result of this core showed low concentration, all of samples were less than 100 grains (table 7). Fern spores dominant by Polypodiaceae and Lycopodiaceae. Non-mangrove pollen of this core consists mainly of herb, such as, Chenopodiaceae, Compositae, Ericaceae and Poaceae. In 97 to 104cm depth Poaceae occurred 80% and may include *Oryza sativa*. Arboreal pollen composed of *Michelia* sp., *Magnolia* sp., *Myrica* sp., *Ulmus* sp. (Nguyen Thi Mai Huong 2006; Nguyen et al. 2007).

Table 7: Pollen analysis of Van Dien core (* Arboreal pollen; ** Non arboreal pollen)

Depth (cm)	Components of pollen-spore			Sum (n)
	Fern spore (n)	AP*	NAP ** (n)	
10	25	8	18	51
20	34	17	13	64
27	2	1		3
35	8	13	7	28
42		2	1	3
50	16	9	10	35
57	12	6	9	27
65			1	1
72	1	1	1	3
80	4	3	1	8
88	17	4	12	33
97	35	9	7	51
104	3	1	37	41
111	12	5	10	27
117	21	4	14	39
125	4		2	6
132				
142				
152	1			1

If we are consider from the depth of 97 to 150cm depth is correspond to the Phung Nguyen culture layer, we can see that in culture layer pollen of NAP (non arboreal pollen) is dominant as compare with AP (arboreal pollen). In addition, pollen of Poaceae occurred 80% (may include *Oryza sativa*) in this layer, and many agriculture tools are found in this site suggested that around 4,000 yr BP rice cultivation was existed in this place.

4.1.2.2. Go Chien Vay core

Go Chien Vay (Chien Vay hillock) is located at Di Trach Vil., Hoai Duc Dist., Ha Tay Prov (21°03'24"N;105°43'44"E), about 10km far from Ha Noi capital in northwest direction. This hillock rises up from +1 to 2,5m above rice field surface and +7-8m above mean seal level (Fig.21, Tab.4). This site is a cemetery of many periods and covers area of total 60.000 square meters. Artifacts are collected from the excavation in 1971 shown that stone artifacts contained (28.12%), bronze (53.12%), iron (11.56%), burnt soil (17.20%). Cultural layer composed 2 layers: - Go Mun culture and Dong Son culture (Duong Co style) (Phan Trong Kiem, 1971).

In this study, a 180cm depth of sediment is collected from Go Chien Vay site. A total 14 samples was extracted for pollen analysis process. The sediment column (Photo 12), particle size (Fig. 23), pollen analysis results (Tab.8) (Nguyen Thi Mai Huong 2006) are shown below:

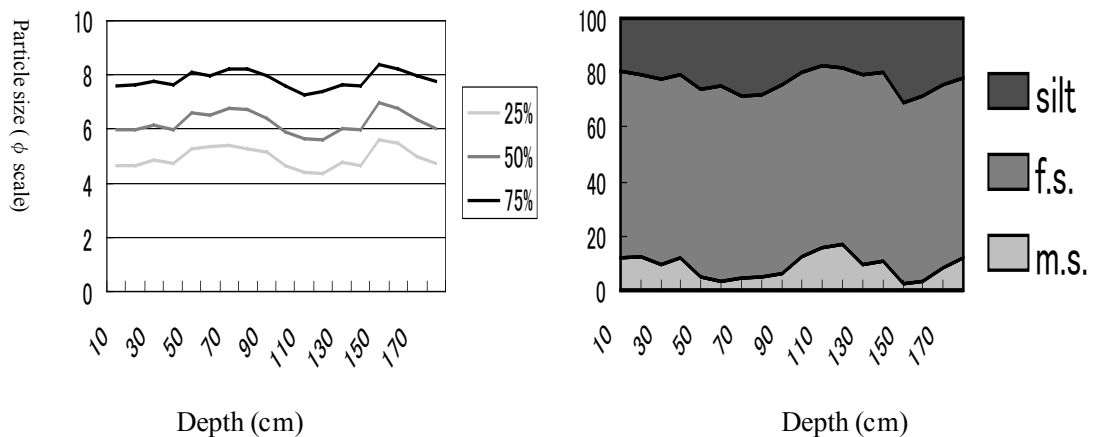


Fig .23: Accumulative percentage and stratigraphy column of Go Chien Vay core



Photo 12: Go Chien Vay's sedimentary core in descending order

Pollen analysis result of this core is characterized by non-mangrove pollen. They are mainly of shrubs and herbs, including Compositae, Chenopodiaceae, Ericaceae, Orchidaceae and Poaceae. *Oryza sativa* is also found but a few number. Pollen of arboreal is rarely found *Carya* sp., *Ulmus* sp., *Michelia* sp., *Magnolia* sp. There are some grains of Gymnosperm like, *Pinus* sp., *Podocarpus* sp. It could be transferred from the mountainous area. No mangrove pollen remains in this core. Result of this core show more detail in table 7 (Nguyen Thi Mai Huong 2006; Nguyen et al. 2007).

Table 8: Results of pollen analysis of Go Chien Vay core (* Arboreal pollen; ** Non arboreal pollen)

Depth (cm)	Components of pollen-spore			Sum (n)
	Fern spore (n)	AP* (n)	NAP ** (n)	
10	21	10	8	39
20	14	14	12	40
28	17	14	5	36
36	5	3	3	11
46				
56	16	11	5	32
66		2	1	3
80	21	9	4	34
87	1			1
97				
107				
117	1		3	4
127	1	3		4
139	11	9	10	30

Pollen analysis results of this core show low concentration, too. And sediment at the depth from 70 to 150cm is considered Go Mun culture layer (around 3,000yr BP.) and Dong Son culture layer (around 2,500yr BP.). Based on the result table, we can see that a few pollen and spore was preserved in the culture layer. Therefore, it is difficult to discuss about an impact of human in this site.

4.1.2.3. Chua Gio core

Chua Gio core is located at Ha Tay Province (20°58'55"N; 105°41'11"E), about 9km far from Ha Dong town in the East direction (Fig.21, Tab.4). This site is laid on Day river bank which rises up to 2m above the surrounding, about 500m far from Day River and 17,5km from Hong River with total about 4000 square meter. This site was studied on June, 1967. Archaeologist determined that artifacts of this site belong to the late Phung Nguyen culture – early Dong Dau culture date to 4,000 yr BP. Most of artifacts are made from stone, include: polished axes, bracelet and potteries (Hoang and Nguyen, 1967).

From 180cm sediment that collected from Chua Gio core, 15 samples were extracted to pollen analysis. The sediment column show in photo 13, particle size in Fig. 24, and pollen analysis of this site is in table 8) are described below.

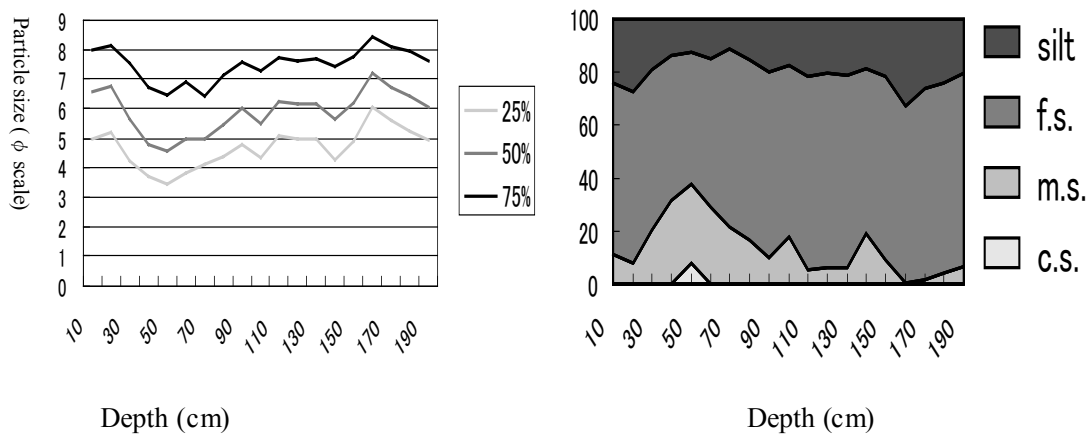


Fig.24: Accumulative percentage and stratigraphy column of Chua Gio core



Photo 13: Chua Gio's core sediment in descending order

Pollen analysis results of this core also show low concentration (Tab.9). Except a few fern spores, arboreal pollen and non- arboreal pollen existed at surface layer (from 0 to 30cm depth), the other part of core is empty of pollen and spore. Therefore, the information may apply to reconstruct the vegetation of this site is limited.

Table 9: Results of pollen analysis of Chua Gio core (* Arboreal pollen; ** Non arboreal pollen)

Depth (cm)	Components of pollen-spore			
	Fern spore (n)	AP* (n)	NAP ** (n)	Sum (n)
10	27	19	16	62
20	15	15	14	44
30	12	3	13	28
40				
49			2	2
58		2	1	3
72				
88				
98				
108				
120				
130	16	3	7	26
140				
148				
156				

Pollen analysis results of this core show low concentration. Based on the result table, we can see that a few pollen and spore was preserved in the culture layer. Therefore, it is difficult to discuss about an impact of human in this site (Nguyen Thi Mai Huong 2006; Nguyen et al. 2007).

4.1.2.4. Bai Tu core

Bai Tu site (Fig. 21, Tab.4) is located at ancient hillock belongs to Tieu Thuong village, Tuong Giang Commune, Tu Son district, Bac Ninh province (21°07'55"N; 105°58'53"E in 10m of elevation), which covered about 2000 square meters. Archaeologists found a thousand stone drills, flacks, saw blades, quadrangular axes and other objects. Based on the artifacts, they reported that this site had been a settlement place and contemporaneous was stone workshop, dated around late Phung Nguyen – early Dong Dau (3,500 to 3,000yr BP.) (Nguyen Kim Dung 1983).

From 140cm of sediment is taken from Bai Tu site, total 12 samples was extracted to pollen analysis process. The sediment (Photo 14), particle size examination results (Fig. 25), and pollen analysis result (Fig. 26) are shown below:



Photo 14: Bai Tu's sedimentary core in descending order

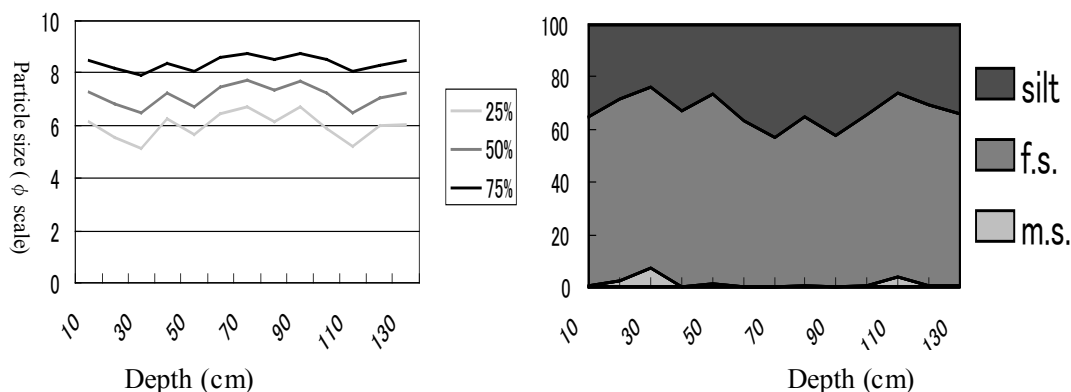


Fig.25: Accumulative percentage and stratigraphy column of Bai Tu core

Pollen of this core showed that fern spore is dominated mainly by Selaginellaceae, Lycopodiaceae, Polypodiaceae. Non mangrove pollen is composed of Compositae, Poaceae, Ericaceae, *Lithocarpus* sp., *Magnolia* sp., *Michelia* sp. Some grains of *Abies* sp., *Pinus* sp., *Metasequoia* sp. may be transferred from the mountainous area. It is worth paying attention to the fact that pollen of Poaceae was in high percentage and with size equal to or bigger than 30 μm presented in this core.

The diagram (Fig. 26) show pollen and spore accumulated quite similar and it is divided into 4 zones based on the result.

In zone 1: Fern spores and herb dominant whereas tree pollen is few;

Zone 2: Fern spores occupied in high percentage, dominated by *Lygodium* sp. and Polypodiaceae, and common of *Microlepia* sp. and *Stenochlaena* sp. Tree pollen also existed more than zone 1 that is characterized by Magnoliaceae and temperate tree like *Alnus* sp. and *Abies* sp., Poaceae pollen is reduced as compare with zone 1 whereas Compositae is become more abundant;

Zone 3: In this zone both herb pollen and fern spore increased, tree pollen in stable stage;

Zone 4: This zone shows the same status like zone 3. Poaceae pollen preserved in zone 3 and 4 provided clear evidence of rice cultivation it show by both numerous of pollen grain and their size (Nguyen Thi Mai Huong 2006; Nguyen et al. 2007).

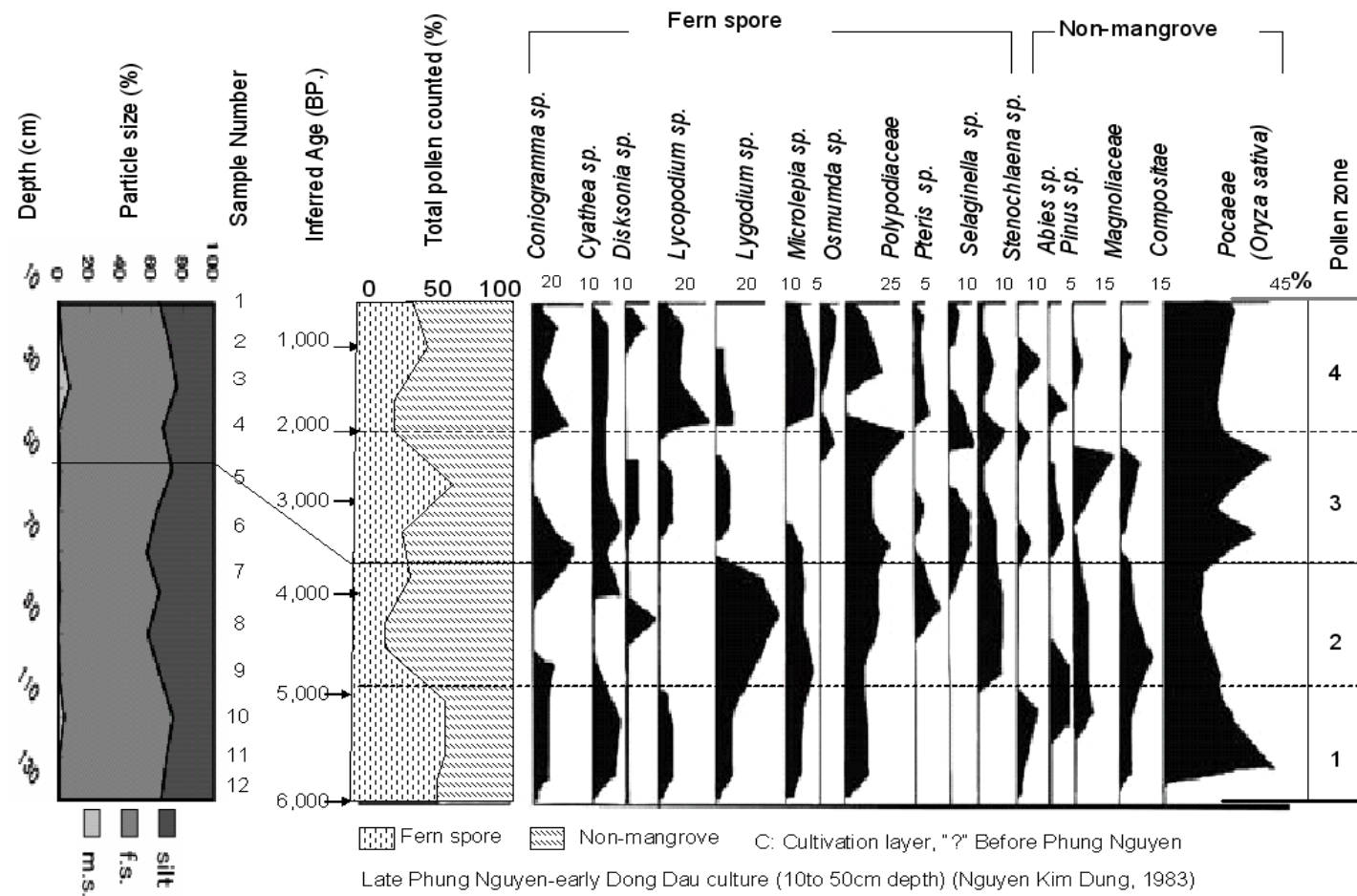


Fig .26: Pollen diagram selected of main taxa in Bai Tu core

Concluding remarks

Based on geographical conditions with availability ecosystem, ancient residents had moved down from the higher area to settled in the Red River Delta and Northern central coastal plain. They are adapted to the environment from the mountainous in Hoa Binh and Bac Son culture (Neolithic) to valley, deltas and coastal environment in Pre-Dong Son culture (Bronze Age). When comparing the number of sites of Neolithic and early Metal age, the number of Metal age sites has increased (Nishimura, 2007). The presence of metal has brought great changes in the lives of the ancient inhabitants in North Vietnam in general and in the river basins in particular. The archaeologists have found a diverse set of tools were made mostly from stone and metal, according to the specialized functions of the artifact, it may used for farming purpose, such as plow, hoes, reapers including sickle, tweezers, knives, axes, chisels,...(Chu Van Tan 1979; Han Van Khan 2004). These tools not only on functions used in agricultural, but also can be used to cut the trees to make boats and other objects created for use in their lives.

Based on the pollen analysis from archaeological sites mentioned above (though in low concentration), it suggested that the flora of Northern Vietnam in Pre Dong Son period is a combination of herbs, shrubs and primary forest, it not much different to Neolithic period. They are mostly tropical plants, prefer hot and humid climate. In a number of archaeological sites, spores was dominates especially at lower layer this phenomenon shows wet conditions of the area. The amount of herb pollen such as Poaceae, Compositae,...increasing while percentage of woody plant pollen like Magnoliaceae, *Pinus* sp.... reduce may because of influence of man. The pollen of Poaceae occurred in high percentage with large pollen size in some samples may be related to paddy cultivation and agricultural activities. In addition, at Phung Nguyen culture layer at Dong Dau and Thanh Den sites, archaeologists have found a lot of burnt rice grains. They are the most authentic evidence for agricultural activity and the relationship between humans and vegetation.

4.1.3. The pollen analysis of Dong Son culture

As mention in chapter 2, thanks to the lowering of sea level, the delta is expended and develops. The delta topography is quite low and flat has very favorable conditions for settlement. There are plentiful of Dong Son archaeological sites distributed on diverse terrain form about 2m height, on natural dykes but mostly along the rivers, on the foothills of the high ground near water. Even in lowland areas such as Ha Tay, Hai Phong and Ha Nam, many boat coffins sites were discovered. Dong Son archaeological sites are also distributed on the ancient alluvial plain in Viet

Tri, Lap Thach (Vinh Phu); Yen Phong, Yen Dung, Viet Yen, Hiep Hoa (Bac Giang), Tien Du, Tien Son (Bac Ninh), and forming large clusters, such as: Co Loa relics (Dong Anh, Hanoi) include 6 sites are located between midland and plain in the Red River, Duong River and Ca Lo River basin; and Vinh Quang, Chua Gio and Go Chien Vay clusters are located in the Thanh Tri, Thach That and Hoai Duc (Hanoi) (Ha ed., 1999: 210, Nishimura and Nishino, 2003).



Fig. 27: Location of Dong Son culture sites

In this study, sediment of three Dong Son archaeological sites was collected for pollen analysis. Among them Dong Son site was choose to focus on reconstruction of vegetation and paleoenvironment as case study, in this site several depth cores were taken (it will mention below) the location of these sites show in figure 27, table 4.

4.1.3.1. Phu Luong core

Phu Luong core is located at 20°56'48"N; 105°45'56"E with altitude 4m above mean sea level. The particular interest was the necropolis at Phu Luong, Ha Tay Province (Now so call Hanoi) (Fig.27; Tab.4), where two layers of burials are found that one on top of the other. The lower one had boat-shaped coffins. The burials on top, on the contrary, were without coffins. Probably they came after the area had been filled up. Many bronze artifacts were also found in this site, such as: axes, ploughshares, sickles, bracelets, spears and statue. Stone artifacts are included axes, earring and pestle, etc.

The dating of this site is $2,150 \pm 60$ yr BP. (Bln. 3538) and $2,060 \pm 50$ yr BP. (Bln.3539) (Tab.13) (Pham and Nguyen, 2000). The collection of artifacts suggested that the owner was a farmer. The sediment (Photo 15), particle size (Fig.28), pollen analysis result (Fig.29) are shown below.

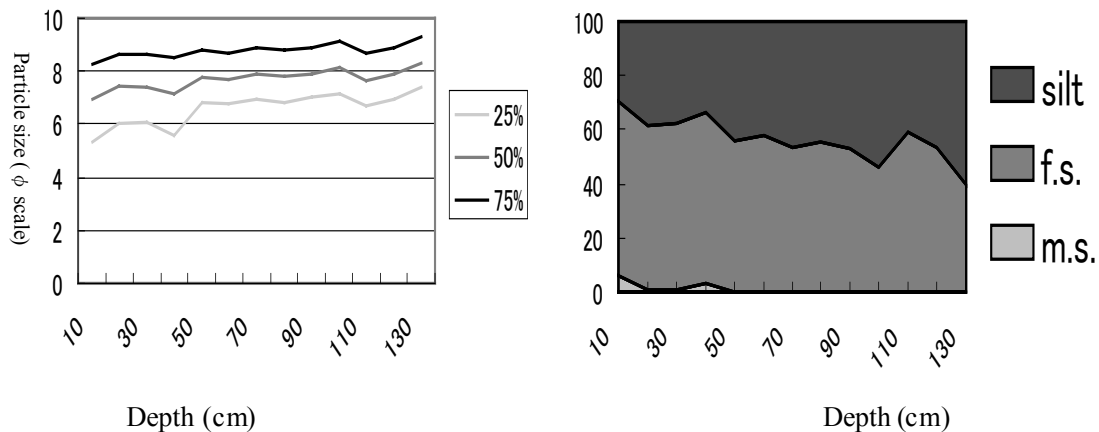


Fig. 28: Accumulative percentage and stratigraphy column of Phu Luong core



Photo 15: Phu Luong's sedimentary core in descending order

The Phu Luong pollen remains were not diverse but present in large of amounts (Fig. 29). Non mangrove pollen are consisting of *Quercus* sp., *Pinus* sp. and *Myrica* sp. record only trace amount, except Poaceae, *Michelia* sp. and *Magnolia* sp. Based on the pollen results four pollen zones are divided. Poaceae including pollen grain have a size bigger or equal 40 μ m was abundant at the depth from 5 to 20cm (zone 4), 60-80cm (zone 3) and 105 to 140cm depth (zone 1). On the other hand, fern spores was well developed and dominated by Polypodiaceae (*Polypodium* sp.) and *Stenochlaena* sp., occurred 93,6% in 75 to 98cm depth (zone 2). Common fern spores of *Coniogramma* sp., *Lygodium* sp., *Lycopodium* sp., and *Microlepidia* sp. besides. The higher value of fern spores in Phu Luong core may reflect humid/wet condition. In this sample, we also found fresh water algae. There was no mangrove pollen in this core (Nguyen Thi Mai Huong 2006; Nguyen et al. 2007)

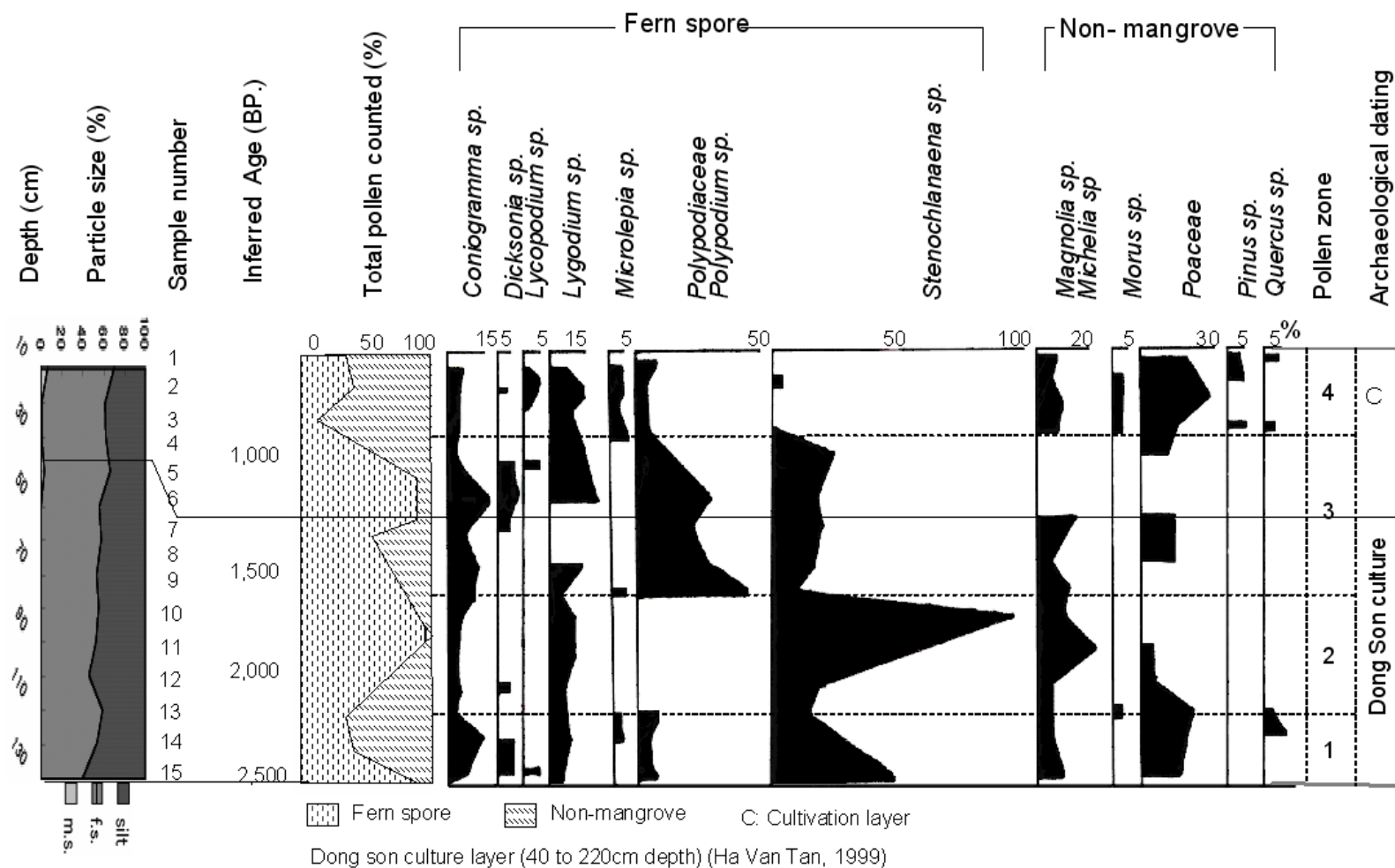


Fig. 29: Pollen diagram selected of main taxa in Phu Luong core

4.1.3.2. Nga Van core

Nga Van core is located at 20°00'07"N; 105°56'54"E with 3m altitude above mean sea level (Fig.27, Tab.4). The site is a sand ridge by nature, now located nearby Nga Van elementary-junior school. This site is not excavation yet. By chance, the teachers and pupils of Nga Van's school have discovered many bronze objects and pottery belonging to Hoa Loc and Dong Son cultures (preliminary conclusion by archaeological investigation team) when they dug some holes to cultivate trees in the school's garden.

From 140cm sediment of this site is taken and total 17 samples are extracted for pollen analysis process. The sediment column (Photo 16), particle size examination (Fig.30) and pollen analysis results of this core (Fig. 31) are shown below:

Result from this core can be divided into 2 zones (Fig.31) (Nguyen Thi Mai Huong 2006; Nguyen et al. 2007):

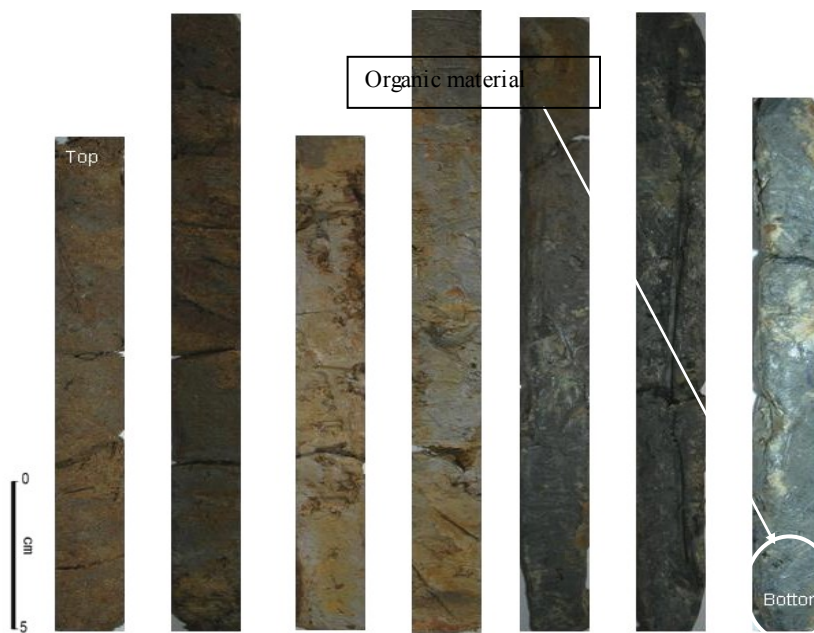


Photo 16: Nga Van's sedimentary core in descending order

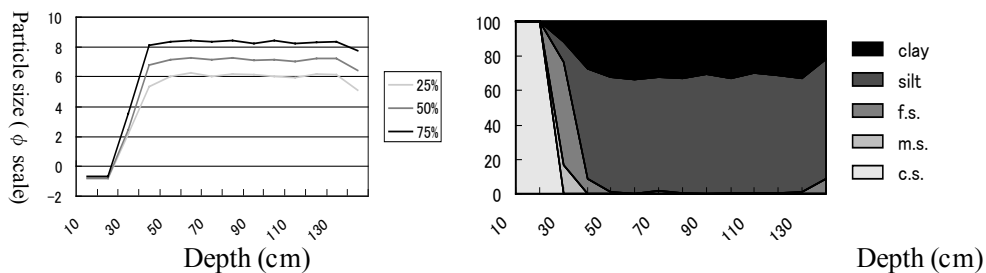


Fig. 30: Accumulative percentage and stratigraphy column of Nga Van core

- Zone 1 (a, b and c), from the depth of 140 to 54cm, the estimate dating of this zone interval 8,000 to 4,000 yr BP (inferred dating). Component of this zone included: fern spores is consisted 4.5- 34.72% common by *Cyathea* sp., Polypodiaceae. Mangrove pollen existed 7.2-44.7% and is characterized by *Rhizophora* sp. (9.7 – 25.7%), *Ceriops* sp. (0-8.9%), *Avicennia* sp. (0-17%). Non mangrove pollen took place 38%-58.9%, pollen of mountainous plants deposited belongs to Fagaceae family like *Quercus* sp (0-4.7%), *Castanea* sp.(0-8.6%), *Castanopsis* sp.(0-5.3%), *Lithocarpus* sp.(0-3%) were higher as compare with zone 2 (will mention below). Pollen of Poaceae was occupied around 15%. AMS dating of this zone is 6174±27yr BP. (PLD.5118) at 96cm depth (Tab.13) that coincide with *Rhizophora* sp. with the highest percentages suggested that the sea level water in high level.

- Zone 2 (a, b): From the depth of 54 to 7cm, the estimate dating of this zone is around 4,000yr BP. to present. Characteristic of this zone is absence of mangrove pollen it mean sea level has reduced and move far to seaward. Percentage of mountainous plant, such as, *Quercus* sp. (0-6.7%), *Castanea* sp.(0-4.5%), *Castanopsis* sp.(0-3.7%), *Lithocarpus* sp.(0-3%) reduced whereas percentage of herb plant pollen is increased, particularly, Poaceae pollen existed in higher percentage (7.5% - 47.6%) include pollen of *Oryza sativa* (22.2%) to comparing with zone 1. Compositae pollen occurred (0-7.68%).

If we consider that the culture layer of Hoa Loc and Dong Son is around 10 to 70cm depth (dated around 4,000 to 2,000yr BP.). We could see that pollen of Poaceae is well preserved and combine with artifacts it can be suggested that Hoa Loc habitants had been practice rice cultivation.

This results shown the same effect with geological results along the Ma River (Tanabe S. et al., 2003a) the paleo – shoreline might be located near the archaeological site (shell midden) at Da But at around 7000 to 6000 yr BP. because the brackish shells obtained from the midden are dated from 5710 ±60 yr BP. to 6430 ±50 yr BP (Pham and Nguyen 2000).

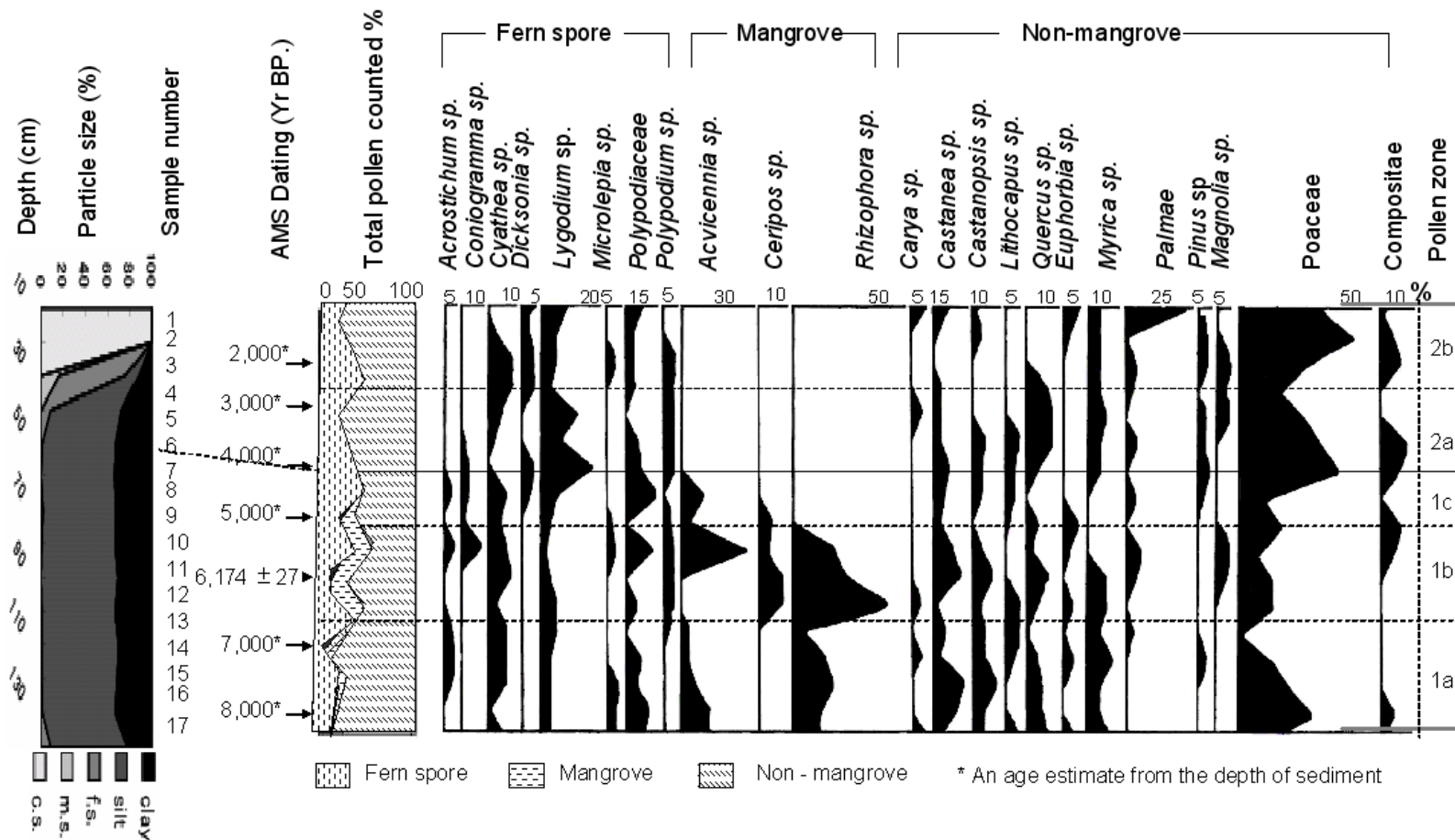


Fig.31: Pollen diagram selected of main taxa of Nga Van core

4.2. Palynological study at Dong Son site

The Dong Son site is located in Dong Son village (Ham Rong Ward, Thanh Hoa city, Thanh Hoa province). The topography of this area created a very good place for people living when the Ma river may supply water, food, transportation, and the mountains make an arc to protect people from the storm, wind and flood (Photo 17,18).

The site was discovered in 1924 when a fisherman chanced upon a number of bronze artifacts at Dong Son village, located on the Ma River. From 1924 to 1932, foreign scholars, such as L.Pajot and O.Janse, excavated this site several times. In 1933, an Austrian scholar, Heine-Geldern, determined that the artifacts came from an ancient culture, which he labeled Dong Son. The origin of this culture, however, was an open question at that time (Ha ed., 1999). Since the 1960s, Vietnamese archaeologists have had the chance to study this site and many other Dong Son archaeological sites, successfully demonstrating that the Dong Son archaeological culture directly developed from Pre-Dongsonian (Bronze Age) cultures. It is high likely that the process was an unbroken, indigenous one, although possible outside influences, such as cross-cultural contact with the contemporaneous Dian culture in Yunnan province, in southwest mainland China couldn't be discounted (Ha ed., 1999, Janse, O. 1967, The new encyclopedia Britannica, 1998:722).

Up to now, Dong Son site have been 8 time excavations, many of artifacts and plentiful archaeological data has been published (Pham, 1996). But no study focusing on historical vegetation changes and the relationship between vegetation and prehistoric subsistence and cultural change exist for this region. Except a research in 2005 taken by author during Master course.

Dong Son site was chooses to focus on study of palynology because of the following reasons: 1- This is typical archaeological site which have a depth and sequences cultural layers (Photo 19); 2- Most of these cores are located on ideal area with the mountain surrounds to protect area from the Ma river, in other hand Ma river provide a favorite condition for people for their settlement such as water supply, food and transportations (Fig.32, Photo 17,18); 3- Frame dating of the site is in late Holocene (Dong Son culture) and it role in pre-historical time in Vietnam particular and Southeast Asian in general.

The goal of this study is reconstructing the vegetation at the Dong Son site utilizing by pollen analysis, and placing this information into larger socio-cultural contexts in North Vietnam, and regional. This is expected to enable us to reveal the pre-historical vegetation in this area like a case study.



Photo17: Major landscapes of Dong Son site

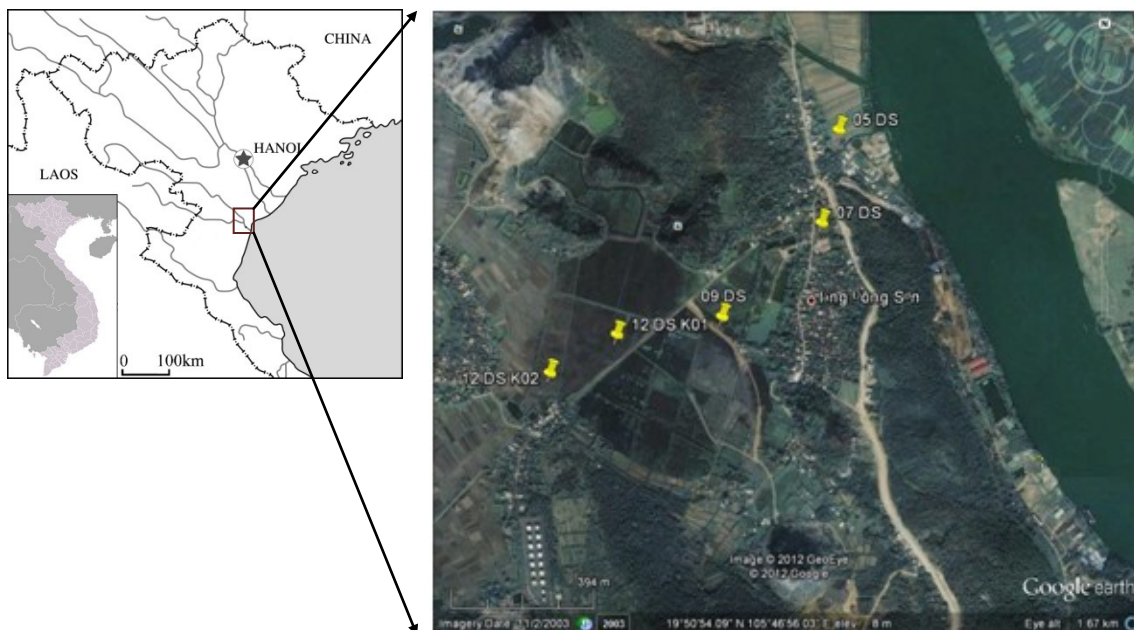


Fig. 32: Dong Son site and location of the cores

Three deep cores were taken at lowland of Dong Son site (Thanh Hoa province) this region mainly affected by wave and sand ridges. They are 09DS, 12DSK01 and 12DSK02 cores, but the core 12DSK01 is not qualified for pollen analysis because of contamination, therefore only 2 deep cores using for this study. Stratigraphy of Dong Son site excavation trench 2007 was also taken for pollen analysis process. Pollen analysis from 05DS core is also used to discuss in this study. The location of these coring sites is show in table 9.

Table 10: Dong Son coring sites and their locations

Core name	Location	Altitude (m asl.)	Core depth (cm)
05DS	19°51'17"N;105°46'58"E	4-5	230
07DS	19°52'1.70"N;105°46'58.75"E	11	230
09DS	19°50'53.78"N; 105°46'49.52"E	4	900
12DSK02	19°50'816"N;105°46'558"E	2.5	700



Photo 18: A view of lowland part of Dong Son village where 3 deep cores been taken



Photo 19: Some artifacts found at Dong Son site (Thanh Hoa Museum) taken by Nguyen Thi Mai
Huong

Table 11: Detail of lithology of the cores

Depth (m)	Altitude (m)	Description
Core 05DS (19°51'17"N;105°46'58"E, ground altitude: 4-5 m)		
0.00-0,4	4.5 to 4.1	Silty clay have small rootless, Hue 10YR6/4
0.4-1.2	4.1 to 3.3	Silty sand, small rootless
1.2-1.4	3.3 to 3.1	clay
1.4-2.3	3.1 to 2.2	Clay and organic material
Core 07DS (19°52'1.70"N;105°46'58.75"E, ground altitude: 11 m)		
0.00 – 0,26	11 to 10,74m	Surface soil in reddish yellow color
0.26-0,56	10,74 to 10,44	Reddish yellow clay with few sand, many fragments of pottery and brick
0,56-0,96	10,44 to 10,04	Blackish brown clay with few sand, many fragments of pottery
0,96-1,14	10,04 to 9,86	Dark brown clay (Hue 2.5Y 3/2), few artifact
1,44-1,25	9,86 to 9,75	Grayish clay, few artifact
1,25-1,60	9,75 to 9,40	Coarse and reddish brown clay may bring from other place. No artifact
1,60-1,88	9,40 to 9,12	Grayish clay, no artifact
1,88-2,23	9,12 to 8,77	Bluish yellow clay, no artifact
Core 09DS (19°50'53.78"N; 105°46'49.52"E, ground altitude: 4 m)		
0,00-1,60	4 to 2,4	Fine clay in dark brown (Hue 2.5Y 3/2), some charcoal fragments
1,60-3,60	2,4 to 0,4	Fine clay with a lot of charcoal (wood charcoal) and sulfur may related to human activity
3,60-5,20	+0,4 to - 1,2	Fine clay with a lot of charcoal and organic material, dark brownish (Hue 2.5Y 3/2),
5,20-6,20	-1,2 to -2,2	Mud including a lot of organic material (herb remain), black color (Hue 7.5YR 1.7/1).
6,20-7,0	-2,2 to -3,0	Waterlog (marine sediment?), lot of sand, organic fragment and laterite coarse
7,0-9,0	-3,0 to -5	Natural laterite soil in red and reddish orange color
Core 12DS K02 (19°50'816"N;105°46'558"E, ground altitude: 2,5 m)		
0,00-1,1	2,5 to 1,4	Gray and grayish white clay
1,1-1,5	1,4 to 1,0	Grayish yellow clay
1,5-2,0	1,0 to 0,5	Grey and grayish white clay
2,0-2,1	0,5 to 0,4	Dark grey clay with plant remains
2,1-4,1	+0,4 to -1,5	Dark grey clay with plant remains
4,1-4,7	-1,5 to -2,2	Grayish pinky clay with black dotted
4,7-5,4	-2,2 to -2,9	Fine sticky clay
5,4-6,0	-2,9 to -3,5	Silty clay
6,0-6,5	-3,5 to -4,0	Fine sticky clay
6,5-7	-4,0 to -4,5	Coarse

4.2.1. Pollen analysis from 05DS core

05DS core is located on along of the Ma River bank, coordinated at 19°51'15"N; 105°46'58"E in +4 to 5m above mean sea level (Fig.32; Tab.10, 11). The sediment column is show in photo 20, table 11. A result of particle size examination is show at figure 33 and pollen analysis results show in figure 34 (Nguyen Thi Mai Huong 2006, 2012).



Photo 20: 05DS's sedimentary core in descending order (Nguyen Thi Mai Huong 2006, 2012).

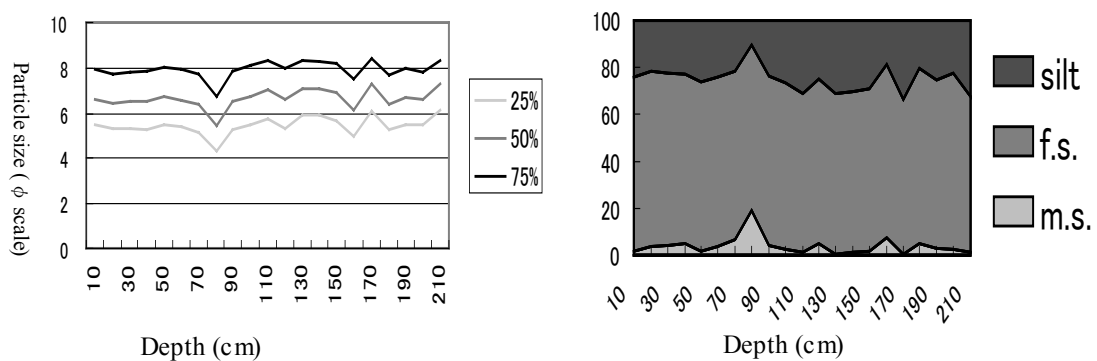


Fig.33: Accumulative percentage and stratigraphy column of 05DS core (Nguyen Thi Mai Huong 2006, 2012).

Zone 1 (188cm – 80cm) is characterized by a fern spore composed of *Cyathea* sp., *Lygodium* sp., *Acrostichum* sp., and *Stenochlaena* sp...Mangrove pollen is consisting mainly of *Avicennia* sp., *Bruguiera* sp., *Ceriops* sp., *Rhizophora* sp., and *Sonneratia* sp.. Non-mangrove pollen is including *Castanopsis* sp., *Quercus* sp., *Pinus* sp., and Poaceae; - AMS dating of this zone 1 is c. 6,169±28 yr BP (PLD.5117) at 188cm depth, and 5,312 ± 26 yrBP (PLD.5116) at 128 to 132 cm depth (Tab. 13). Pine pollen appearing in this zone suggests that there may have been a short lived temperature reduction after c. 5000 BP;

Zone 2 (from 80-5cm) is characterized by fern spores content up to 46.07%, including: *Cyathea* sp., *Microlepia* sp., and Polypodiaceae. Mangrove species being entirely *Rhizophora* sp. Non-mangrove pollen is dominated by Poaceae, Compositae, *Euphorbia* sp., Palmae, *Michelia* sp., *Myrtus* sp., and *Myrica* sp. Pollen of *Sonneratia* sp. appeared in this zone, suggesting that this area was a lagoon at that time (Thai, 1978; Phan, 1999).

In zone 1 mangrove pollen is dominant, components of mangrove pollen reflect that zone 1a had been a swamp area and was affected by brackish water, pollen in this zone abundance by Rhizophoraceae. Whereas, in zone 2 the percentage of Poaceae is higher than it in zone 1 with larger pollen grain sizes (Nguyen Thi Mai Huong 2006, 2012).

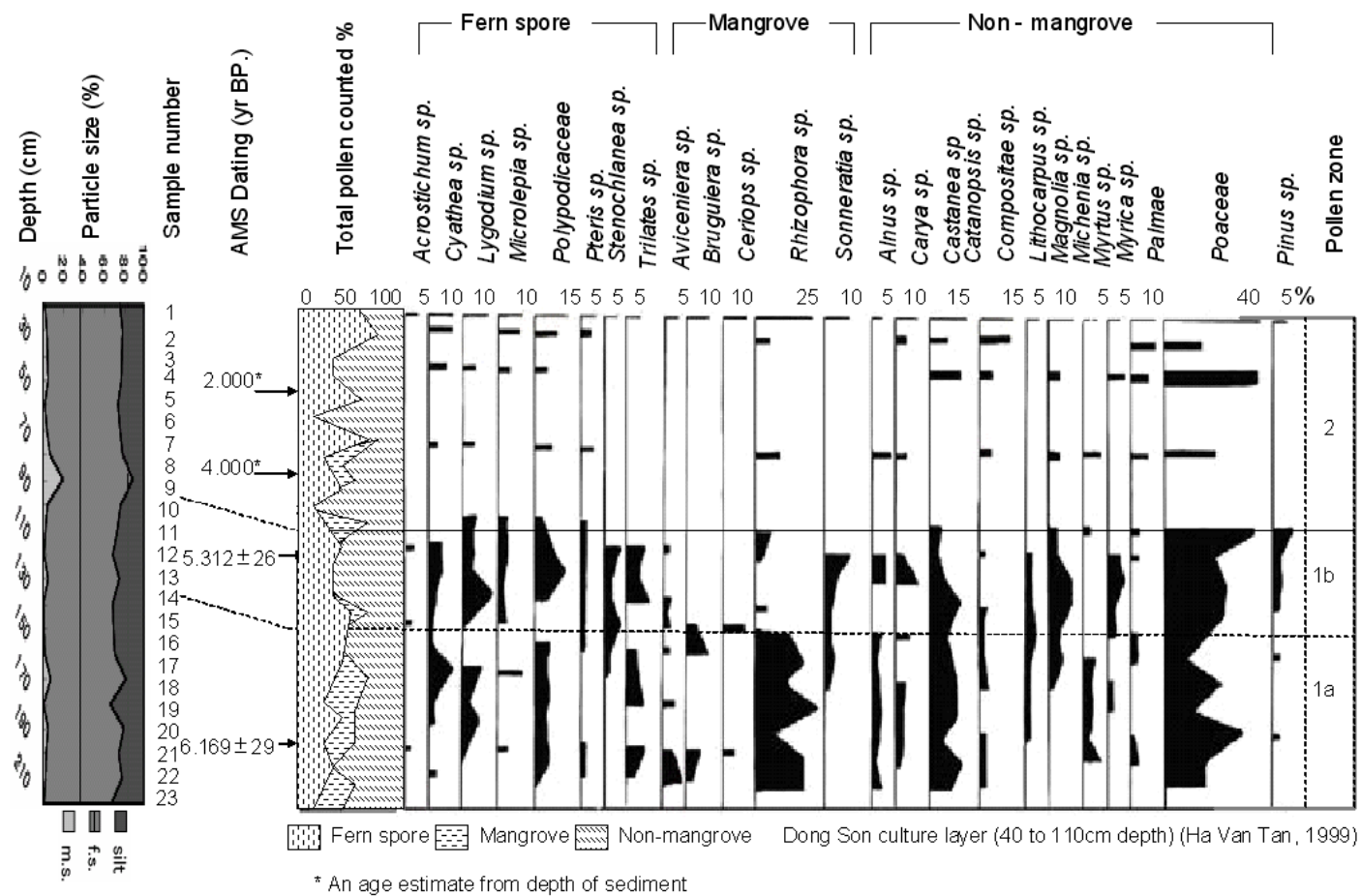


Fig .34: Pollen diagram selected of main taxa of 05DS core (Nguyen Thi Mai Huong 2006, 2012)

4.2.2. Pollen analysis from 07DS section

The 8th excavation trench is located at the high land of the site, in the Dong Son village now where several studies been operation. The coordinate of this site is 19°52'1.70"N; 105°46'58.75"E, altitude 11m above sea level (Fig 32; Tab.10, 11). The cultural remains of this site unearthed in a vast area, including traces of thick cultural layer, many bronze objects like axes, point, fish hook,...and density of pottery mostly belongs to Dong Son Culture (Photo 21). In addition, we also found stone tools, earthenware, and other artifacts have dating earlier or later are also discovered.



Photo 21: Dong Son artifacts (Thanh Hoa Museum) taken by Nguyen Thi Mai Huong

Lithological of this profile is described in table 10, based on the change of sediment and the cultural layer 13 samples was extract for pollen analysis (Photo 22). All samples was treat by pollen analysis method, from abundance variations of the principal pollen and spores species, three pollen zones are identified (see Fig.35). The sediment grain test also did and show in appendix 1.

- Zone 1: from the depth of 230cm to 180cm, there is little pollen reserved in this zone. The sediment of this zone is clay in blue and yellow colour. There is no artifact found (see photo 22). It may because of the sediment at that time was exposed, the oxidation process was destroyed all organic material including pollen grain.

- Zone 2 (from the depth of 180cm to 90cm), sediment of this zone is mostly darkish brown clay with laterite particle, very few artifacts was found in this zone. Pollen analysis result of this zone show low preservation and less diversity of species. It characterized by a fern spores composed of *Cyathea* sp., *Polygodium* sp...; there are few pollen of arboreal appeared in this zone, including *Liquidambar* sp., *Rubiaceae*, *Sapindus* sp., non-arboreal pollen represented of *Poaceae* and *Digitaria* sp...

- Zone 3 (from the depth of 90cm to 30cm), we have been found dense of pre historic pottery and many other kind of artifacts in this zone. Pollen analysis of this zone show dominated consist of non-

arboreal pollen such as Poaceae (15%), Compositae, and *Leleba* sp.; Number of arboreal pollen is larger than unit 2 and more diverse, they are represented by *Quercus* sp., *Castanopsis* sp., Rubiaceae, Myrtaceae,...And fern spore is mainly of *Polypodium* sp., Polypodiaceae, *Cyathea* sp., *Coniogramme* sp., ...

The result is suggested that this area is quite dry environment and located in high place, as compare to another core in lower one. At the upper part, the percentage of Poaceae is increased with large size of pollen grain. This might relate to cultivation activities. And indicate that this time is wetter than before.

We did not found any affect of sea in this place, it may due to the high of the site. Own to this condition this place is very good for people living for long time that is why the archaeological artifact found very dense in this area.



Photo 22: Profile of 07DS excavation trench (taken by the late Dr. Nishimura Masanari)

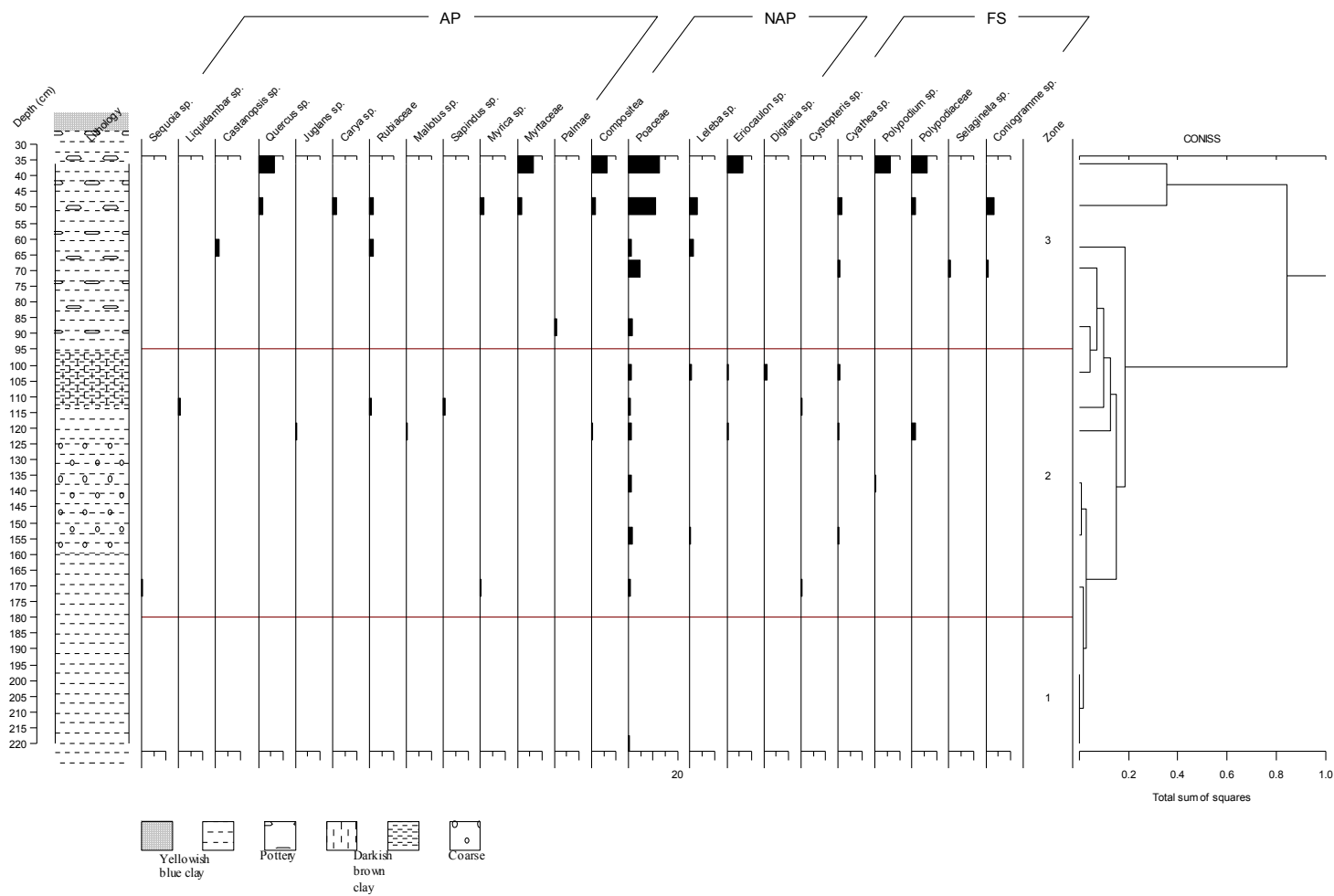


Fig.35: Pollen diagram of selected taxa of 07DS profile

4.2.3. Pollen analysis from 09DS core

The 09DS core is taken at lowland of Dong Son site, coordination 19°50'53.78"N; 105°46'49.52"E, altitude 4m above sea level (Fig.32; Tab. 10, 11). This place is seasonal inundation especially in summer time and often flood after rain. The local people using some parts of this area to cultivation vegetable, mostly aquatic plant like *Ipomoea aquatica* Forssk , *Dioscorea* sp....for food or feed castles.

The sediment of this core is mostly very fine silty clay with small fragments of charcoal (Fig.36; Photo 23, 24), acid sulphate soil may appear at the depth from 2 to 3m (photo 25). Thirty four samples were extracted from the depth of 50 to 670cm for pollen analysis.



Photo 23: Sampling samples



Photo 24: Charcoal particles in the core



Photo 25: Acid sulphate soil

Loss on ignition of this core averages around 15-20% (Fig.37). There is a peak of organic carbon at 6m corresponds with blackish silty clay with a lot of organic material (Photo 26).

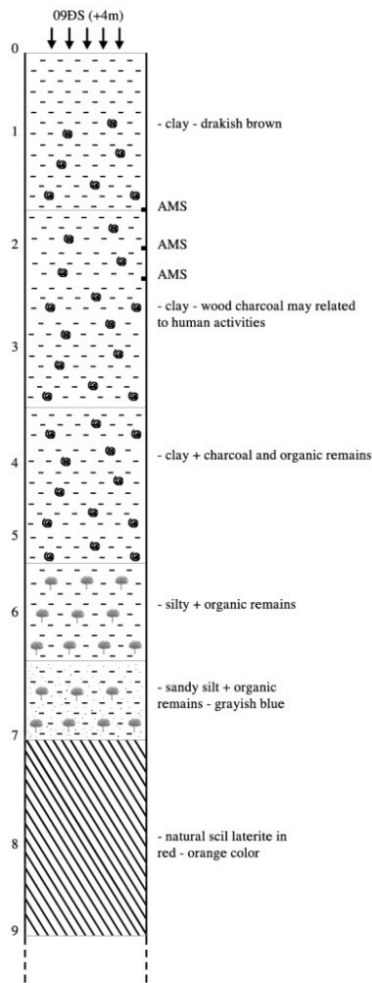


Fig.36: Lithology of 09DS core

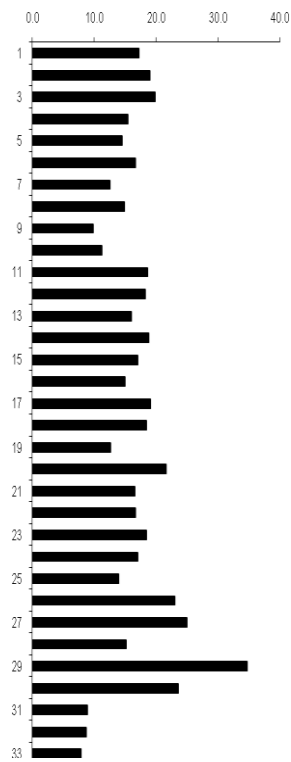


Fig.37: Loss of ignition of 09DS



Photo 26: 09DS's organic sediment

Zone 1: From the depth of 6.7m to 5.8m, sediment of this zone is sandy silt and grayish blue clay. This phenomenon may indicate that at that depth, sediment was exposed long time. The oxidation process has destroyed all organic material in the sediment, including pollen grains. Therefore very few pollen grains preserved. AMS dating from 600cm depth is $6,730 \pm 25 \text{yrBP}$ (PLD.20930) (Table 13).

Zone 2: from the depth of 5.8m to 2.5m, pollen show low concentration, arboreal pollen is existed of *Castanopsis* sp., *Quercus* sp....very few grains of non arboreal pollen are found, but spores is dominated mainly of *Cyathea* sp., *Polygodium* sp., *Gleichenia* sp.,... The characteristic of this unit is presenting of mangrove pollen mostly of *Rhizophora* sp., and *Acrostichum* sp. spores reflect that area had been a swamp place and was affected by brackish water. AMS dating of this

zone are $6,150 \pm 25 \text{yrBP}$ (PLD. 20928) at 315cm depth and $5,940 \pm 25 \text{yrBP}$ (PLD. 20929) at 510cm depth (Tab.13).

Zone 3: from the depth of 2.5m to 1.5m, pollen show low concentration as similar to zone 2. Arboreal pollen is existed of *Castanopsis* sp., *Quercus* sp....very few grains of non arboreal pollen are found. The characteristic of this unit is presenting of mangrove pollen mostly of *Rhizophora* sp. Spores is dominated mainly of *Cyathea* sp., *Polygodium* sp., *Gleichenia* sp.,... reflect that area had been a swamp place and was affected by brackish water. AMS dating of this zone is $5,586 \pm 25 \text{yrBP}$ (PLD. 24937) at 180 cm depth (Tab.13).

Zone 4: From the depth of 1,5m to 0,20m, pollen and spores found in this unit are mostly herbaceous, such as pollen of Poaceae (occurred more than 60%) with grain size is quite big (30-40 μm), *Typha* sp., Cyperaceae and Compositae. Especially in this unit, the arboreal pollen, such as *Castanopsis* sp., *Quercus* sp., and *Magnolia* sp., are also accounted with a significant number. There is few pollen of mangrove appeared in this unit, it suggested that the environment had been change from swampy brackish to alluvial environment. Charcoal particle appeared in this zone is indicated human disturbed at that time and $5,550 \pm 25 \text{yrBP}$ (PLD. 24936) at 123cm depth (Fig.36, Photo 24).

The pollen analysis and AMS results is suitable with geological archived that around 6,000-7,000 yr BP the sea level at high stand at about +3 to +4m above mean sea level. This evidence also suggested that Dong Son people have started to settlement in this site must be later than this time. Pollen of herb plants increased while pollen of arboreal reduces due to human activities from 1,5m depth.

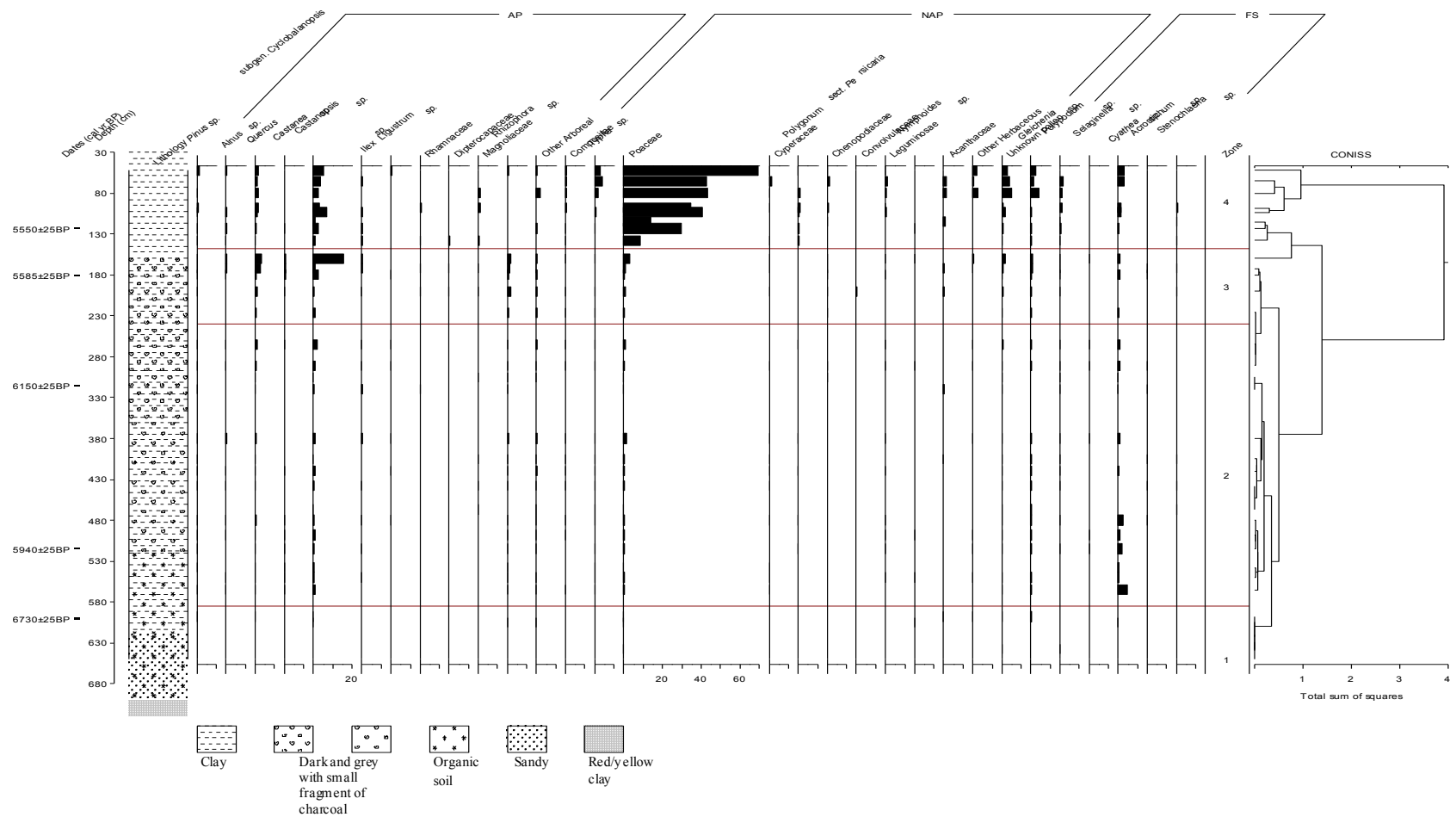


Fig.38: Pollen diagram of selected taxa for 09DS core

4.2.4. Pollen analysis from 12DSK02 core

In July 2012, the 2 deep cores have been taken at the lowland of Dong Son village (Fig.32; Tab. 10, 11). The first core name 12DSK01, located at $19^{\circ}50'851''\text{N}$; $105^{\circ}46'645''\text{E}$, altitude 2.5m above sea level; the second core name 12DSK02, located at $19^{\circ}50'816''\text{N}$; $105^{\circ}46'558''\text{E}$, altitude 2.5m above sea level. After checked sediment, we found that the core 12DSK01 was contamination, it's not qualifies for pollen analysis, and therefore only sediment of core 12DSK02 was use in this study.

The lithological of this core show in table 10, (figure 39). Loss on ignition of this core is indicating organic carbon averages around 20% (Fig.40). It increases below the depth of 1,5m. There are two peaks of organic carbon at 3m and 4,5m corresponds with darkish gray clay. Pollen analysis result show that pollen preserved begins at about 580cm depth, below this depth of sediment are essentially sterile and most of the few pollen grains found are corroded. It may also that a surface suitable for pollen deposition and preservation was not formed.

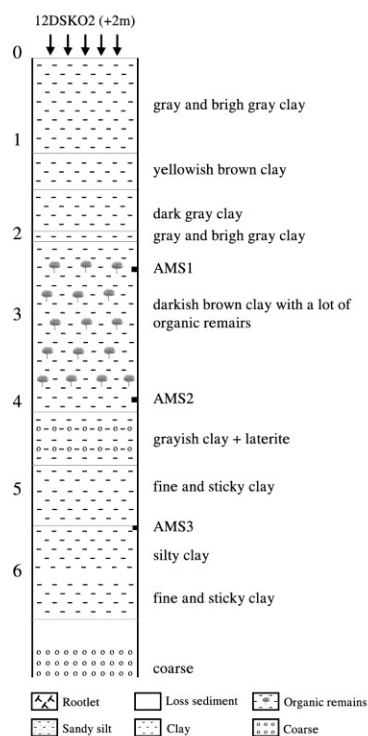


Fig.39: Lithology of 12DSK02 core



Fig.40: Loss of ignition of 12DSK02



Photo 27:
12DSK02's
sediment

The pollen analysis result of 12DSK02 core can divided into four zones (Fig.41)

Zone 1: from the depth of 680cm to 580cm, this zone show few pollen and spores reserved.

Zone 2: from the depth of 580cm to 450cm, dominant of this zone is spores of Pteriophyta, very few AP pollen existed in this zone they are *Castanopsis* sp., and *Ilex* sp. Mangrove pollen is scatter with few amount, it indicated that this part is fresh water environment. AMS dating of this zone is $7,043 \pm 56$ cal BP (AA 100307) at 564cm depth (Tab.13).

Zone 3: From the depth of 450cm to 100cm, this zone show diverse of pollen and spores reserved. Pollen of AP is dominant with mainly of *Quercus* sp., *Castanopsis* sp., and other Fagaceae it may indicated that time is high rain fall, some grains of *Betula* sp. and Actidiaceae are also found. Pollen of non arboreal presented such as Compositae, Cyperaceae, *Polygonum* sp., and Poaceae. It may indicate this area is inundation place. Mangrove pollen appeared in this zone only, dated $4,810 \pm 45$ cal BP (AA 100306) at 401cm depth and $3,898 \pm 43$ cal BP (AA 100305) at 261cm depth (Tab.13). It shows this area affected by sea level change during 5,000-3,000 yr BP. Spores also occurred in high percentage it may indicate this area is inundation place and brackish environment.

Zone 4: From the depth of 100 cm to the surface, this zone is dominant of NAP pollen, especially of Poaceae, this kind of pollen existed up to 50% or more in the surface layer. Pollen of Cyperaceae and Compositae are also abundant. Pollen of AP reduce in number if compare to zone 3. It may due to human activities.

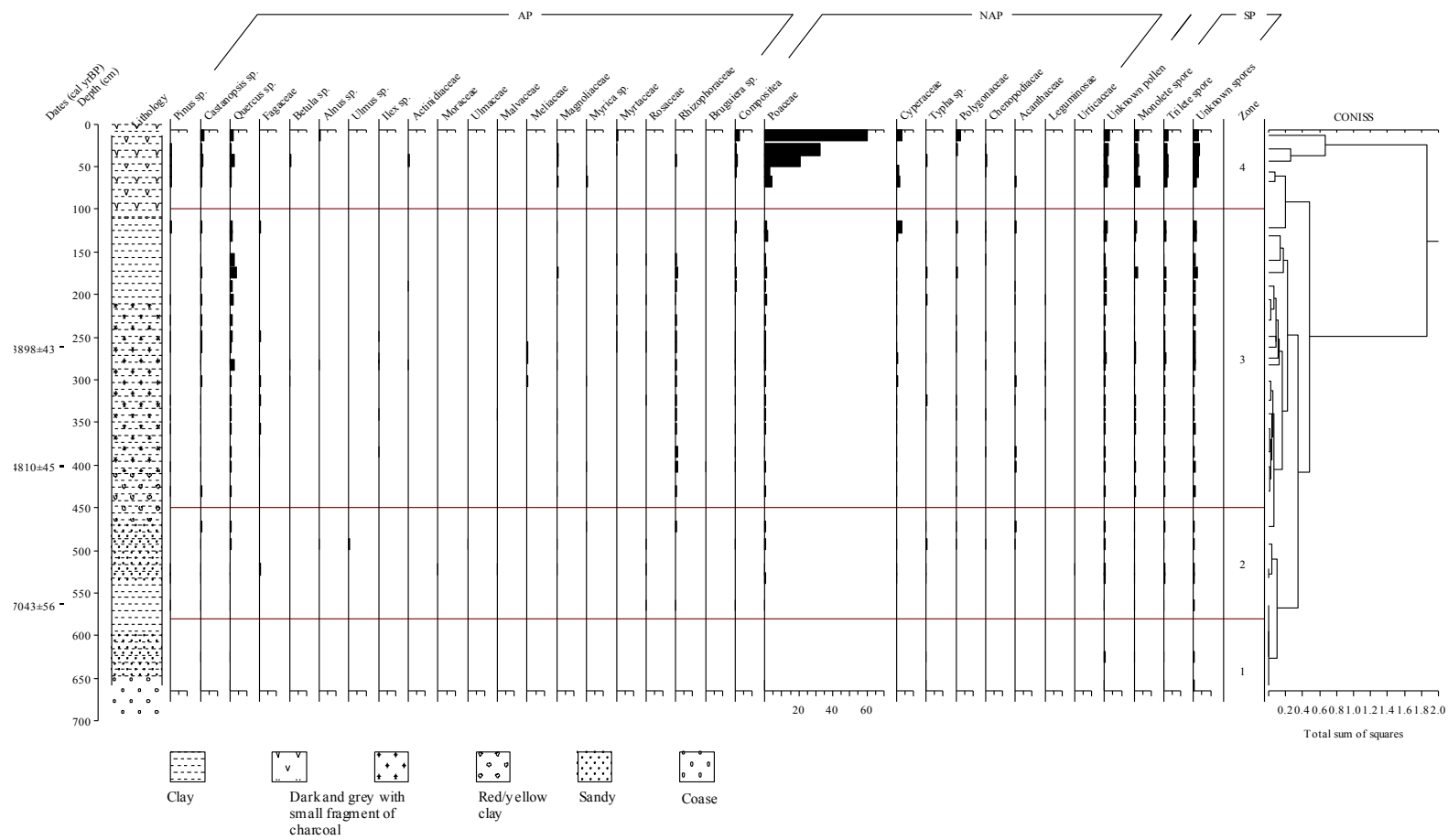


Fig.41: Pollen diagram of selected taxa for 12DSK02 core

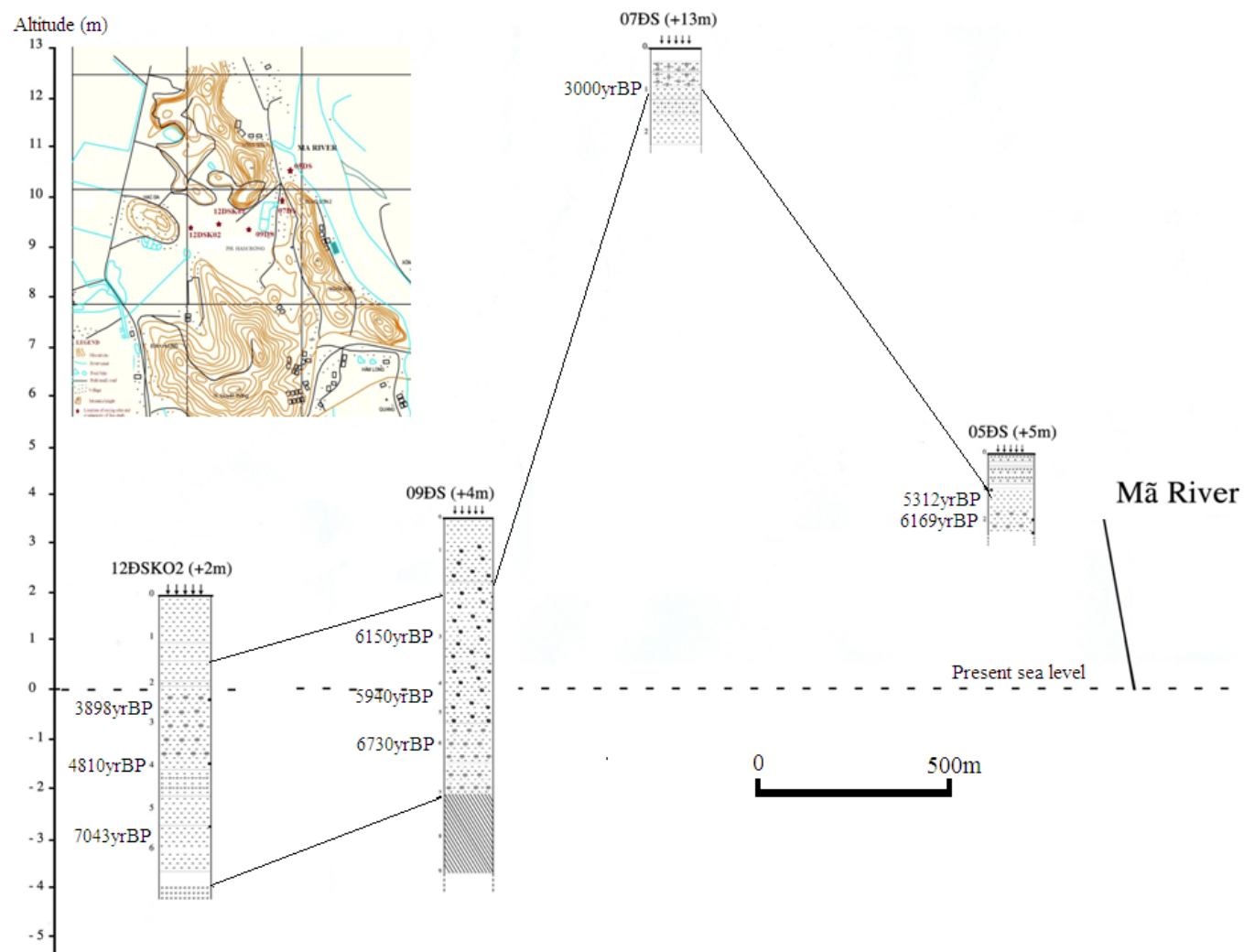


Fig.42: Sediment cores at Dong Son site

Concluding remarks

Through pollen analysis result from the core 05DS is located at the Ma River bank (Nguyen 2006) and 09DS, 12DSK02 cores are located at lowland of Dong Son site, we have been found mangrove species presented at about 1 to 6m depth, they are mainly of *Rhizophora* sp. and *Bruguiera* sp., ...dated around $4,810 \pm 45$ yrBP to $7,043 \pm 56$ yrBP (Fig.42). It indicates, at that time sea levels had affected this area and covering in shallow tides for long time. After this time, mangrove pollen gradually reduced within the core samples, corresponding to the period between c. 5,000 - 4,000 BP. and disappears between c. 4,000 - 3,000 BP. It can be concluded that the seashore had transgressed far enough to form the present coastline by this period.

The upper parts (from the surface to 1-2m depth date about c. 3,000-2,000 BP.) of all diagrams are dominated by grass pollen grains. The fern spores record consisted of *Lygodium* sp., *Polypodium* sp., *Cyathea* sp.; Polypodiaceae, *Stenochlaena* sp., and *Microlepia* sp., The arboreal pollen types are mainly a mixture of indigenous lowland monsoon forest species such as *Castanea* sp., *Castanopsis* sp., *Lithocarpus* sp., *Magnolia* sp., *Michelia* sp., *Quercus* sp., Palmae, *Myrtus* sp and with some pine (*Pinus* sp.). The amount of pine pollen is so low, it suggested that pine was growing somewhere near the site. Non arboreal pollen in the all cores are dominant, particularly that of Poaceae is increased, whereas the gradual reduction of arboreal pollen may due to human land clearance. The presence of Poaceae pollen in all pollen diagrams were dominated by both large (above 30 to 40 microns in diameter) and small grains may include *Oryza sativa*. And moreover we found the traces of rice imprinted in Dong Son pottery (Photo 19), it provides yet more evidence demonstrating that agricultural activities occurred around the Dong Son site at that time (Fig.34, 35,38,41)

From the archaeological evidence, it is clear that the site was occupation from about c. 3,000 yr BP and from the cores we have found carbonized particle from 1-3m depth (09DS) (Photo 24). The carbonized particle is evidence for disturbance of the vegetation, dating might around the same time with man occupation in this area.

It is very difficult to extract meaning of climatic data from the change to non-mangrove vegetation. All that can be said is that, with the decline in sea level from a post-glacial high of perhaps 3m above present sea level, a large area of land in North Vietnam including Red River delta and Ma River delta will have come under more seasonal conditions and this change

probably took place around 4,000-3,500 yr BP and would surely have had most impact on the coastal communities.

There is the fact that, the pollen grains preserved in Dong Son is in low concentration. It may be because of sediment from the cores, sediment form at Dong Son site is mostly clay, silty clay, sandy silt, coarse, laterite and rock in bottom. It's a kind of alluvial sediment. In North Vietnam, this stage began at the end of the Middle Holocene when the shoreline restarted to migrate seaward. In generally, alluvial sediments are predominantly inorganic, although this depends on the nature of the substrate being eroded in the catchment and often contain fossil pollen. The local pollen input depends on the pollen productivity of the floodplain vegetation.

But returning to the site, Dong Son site located near to Ma River, and about 16km from sea coast now. This area is surrounding by low limestone mountain (about 90m), the lowland lies inside the arc of those mountains (Fig.32; Photo 17, 18). It was possible that the physical transport of pollen in inorganic from the Ma river activity often leads to mechanical damage. If the origin of the pollen is the soil cover of the river catchment, then oxidation and microbial degradation is also likely to have led to further pollen deterioration. In the lower reaches of rivers, marine influence may be felt, particularly in the erosion and reworking of the alluvial sediments themselves (Moore et al.1991).

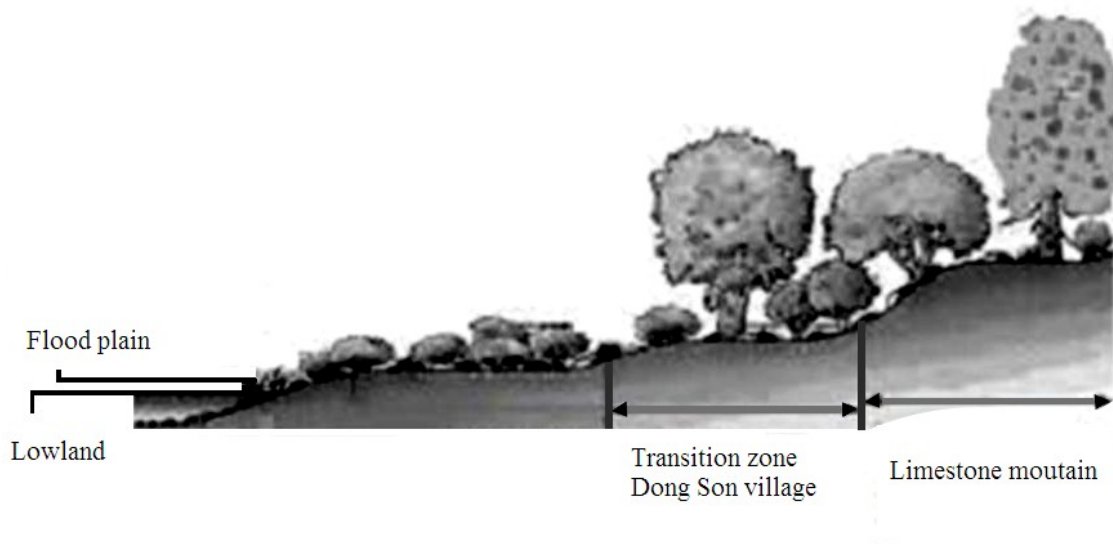


Fig.43: Model of pollen transport by alluvial process and topography of Dong Son site
(Modify after Moore et al. 1991)

Table 12: List of all taxa found from Dong Son cores

Tropical arboreal plant	Subtropical arboreal plant	Temperature arboreal plant	Herb	Fern spore	Mangrove and back mangrove
<i>Acacia</i> sp. (Leguminosae)	<i>Lithocarpus</i> sp. (Fagaceae)	<i>Ulmus</i> sp. (Ulmaceae)	Orchidaceae	<i>Angiopteris</i> sp. (Pteridophyta)	<i>Acrostichum</i> sp. (Pteridaceae)
<i>Aralia</i> sp. (Araliaceae)	<i>Castanopsis</i> sp. (Fagaceae)	<i>Ilex</i> sp. (Aquifoliaceae)	<i>Oryza sativa</i> (Poaceae)	<i>Ceratopteris</i> sp. (Pteridophyta)	<i>Avicennia</i> sp. (Avicenniaceae)
<i>Carya</i> sp. (Juglandaceae)	<i>Liquidambar</i> sp. (Hamamelidaceae)	<i>Quercus</i> sp. (Fagaceae)	Compositae	<i>Coniogramme</i> sp. (Pteridophyta)	<i>Bruguiera</i> sp. (Rhizophoraceae)
<i>Cycas</i> sp. (Cycadaceae)	Fagaceae	<i>Juglans</i> sp. (Juglandaceae)	Poaceae	<i>Cyathea</i> sp. (Cyatheaceae)	<i>Ceriops</i> sp. (Rhizophoraceae)
<i>Engelhardtia</i> sp. (Juglandaceae)		<i>Myrica</i> sp. (Myricaceae)	Malvaceae	<i>Dicksonia</i> sp. (Dicksoniaceae)	<i>Cyperus</i> sp. (Cyperaceae)
Ericaceae		<i>Alnus</i> sp. (Betulaceae)	Liliaceae	<i>Gleichenia</i> sp. (Gleicheniaceae)	Rhizophora sp. (Rhizophoraceae)
<i>Euphorbia</i> sp. (Euphorbiaceae)		<i>Taxodium</i> sp. (Taxodiaceae)	<i>Lilium</i> sp. (Liliaceae)	<i>Hymenophyllum</i> sp. (Hymenophyllaceae)	<i>Sonneratia</i> sp. (Sonneratiaceae)
Euphorbiaceae		<i>Castanea</i> sp. (Fagaceae)	Labiatae	<i>Lycopodium</i> sp. (Lycopodiaceae)	<i>Nypa</i> sp. (Arecaceae)
<i>Glyptostrobus</i> sp.		<i>Abies</i> sp. (Pinaceae)	Leguminosae (Fabaceae)	<i>Lygodium</i> sp. (Pteridophyta)	
<i>Jatropha</i> sp. (Euphorbiaceae)		<i>Pinus</i> sp. (Pinaceae)	<i>Pterocarya</i> sp. (Chenopodiaceae)	<i>Microlepia</i> sp. (Pteridophyta)	
<i>Magnolia</i> sp. (Magnoliaceae)		<i>Metasequoia</i> sp. (Taxodiaceae)	<i>Chenopodium</i> sp. (Chenopodiaceae)	<i>Plagiogyria</i> sp. (Pteridophyta)	
<i>Michelia</i> sp. (Lecythidaceae)			<i>Polygonum</i> sp. (Polygonaceae)	Polypodiaceae	
<i>Morus</i> sp. (Moraceae)				<i>Polypodium</i> sp. (Polypodiaceae)	
<i>Myrsine</i> sp. (Myrtaceae)				<i>Pteris</i> sp. (Pteridaceae)	
<i>Nyssa</i> sp. (Cornaceae)				<i>Selaginella</i> sp. (Selaginellaceae)	
Palmae				<i>Stenochlaena</i> sp. (Pteridophyta)	
<i>Platycarya</i> sp. (Juglandaceae)				<i>Osmunda</i> sp. (Osmundaceae)	
<i>Podocarpus</i> sp. (Podocarpaceae)					
<i>Rhus</i> sp. (Anacardiaceae)					
Rubiaceae					
<i>Sterculia</i> sp. (Sterculiaceae)					
<i>Tilia</i> sp. (Tiliaceae)					

Table 13: Dating of Metal Age archaeological site in Northern Vietnam

Site name	Signed	Depth (cm)	Material	Location	Archeological culture	Lab.No	YrBP	D13C	Note
Quy Chu	2000QC.H2.L2-3	70	charcoal	Thanh Hoa	Quy Chu	HNK-27	2930±80	-26.0	Reference
Quy Chu	2000QC.H1.L2-4	126	charcoal	Thanh Hoa	Quy Chu	HNK-28	2730±80	-25.0	-
Trang Kenh		140-160	Animal bone	Hai Phong	Phung Nguyen	HNK-1	3035±160	-25.0	-
Trang Kenh	86.TK.H1.M1.L8	160	Charcoal	Hai Phong	Phung Nguyen	AA 2772	3280±50		-
Trang Kenh	86.TK.H1.M2.L8		charcoal	Hai Phong	Phung Nguyen	AA 2773	3340±70		-
Trang Kenh	86.TK1.L8		Charcoal	Hai Phong	Phung Nguyen	Bln.3710	3260±150		-
Trang Kenh	I.T.K 69.H1	190-210	Charcoal	Hai Phong	Phung Nguyen	Bln.891	3405±100		-
Trang Kenh	TK.70.HB	140	Organic	Hai Phong	Phung Nguyen	ZK-307	3005±90		-
Trang Kenh	96.TK.H1.L5-2.Cd4	175-190	Charcoal	Hai Phong	Phung Nguyen	ANU-10884	3440±60		-
Phu Luong	PL.84.L1		Wood	Ha Tay	Dong Son	Bln.3538	2150±60		-
Phu Luong	84.VN.H2.M2	210	Wood	Ha Tay	Dong Son	Bln.3539	2060±50		-
Dong Dau	87.DD1	115	Charcoal	Vinh Phuc	Dong Dau	Bln.3811	2830±80		-
Dong Dau	87.DD2	186	Charcoal	Vinh Phuc	Dong Dau	Bln.3810	2960±150		-
Dong Dau	87.DD4	340	Charcoal	Vinh Phuc	Dong Dau	Bln.3711	3050±80		-
Dong Dau	DD99.H1.L6.B8.	160	charcoal	Vinh Phuc	Dong Dau	HNK-29	2955±110	-25.0	-
Dong Dau	DD99.H1.L1.A3	40	Charcoal	Vinh Phuc	Go Mun	HNK-33	2980±130	-25.0	-
Dong Dau	DD99.H1.L15.E6	440	Charcoal	Vinh Phuc	Phung Nguyen	HNK-31	2950±100	-25.0	-
Dong Dau	DD99.H1.L15.E8	340	Charcoal	Vinh Phuc	Phung Nguyen	HNK-32	3500±110	-25.0	-
Dong Son	70.DS.T.S	170-200	Charcoal	Thanh Hoa	Dong Son	Le-983	2830±120		-
Thanh Den	83 TD (6)(L2)	113	charcoal	Vinh Phuc		R.9755/1	2650±130		-
Thanh Den	83 TD (15)(L4))	149	charcoal	Vinh Phuc		R.9755/2	3530±100		-
Thanh Den	83 TD (18).L5	230	charcoal	Vinh Phuc		R.9755/3	3390±70		-
Thanh Den		114	charcoal	Vinh Phuc		Bln.3263	2630±50		-
Thanh Den		115	charcoal	Vinh Phuc		Bln.3261	3090±60		-
Thanh Den		124	charcoal	Vinh Phuc		Bln.3264	3650±70		-
Thanh Den		146	charcoal	Vinh Phuc		Bln.3262	3730±50		-
Thanh Den	84 TD.H.B(5)	115	charcoal	Vinh Phuc		HCM V07/93	3100±65		-

Table 13: Dating of Metal Age archaeological site in Northern Vietnam (continue)

Site name	Signed	Depth (cm)	Material	Location	Archeological culture	Lab.No	YrBP	D13C	Note
Thanh Den		115	charcoal	Vinh Phuc		Bln.2953	2920±70		Reference
Thanh Den		115	charcoal	Vinh Phuc		Bln. 2981	2860±70		-
Thanh Den		138	charcoal	Vinh Phuc		Bln. 2954	2060±60		-
Thanh Den		139	charcoal	Vinh Phuc		Bln.2955	2940±60		-
Thanh Den	83 TD (15)	149	charcoal	Vinh Phuc		Bln.2956	3350±50		-
Thanh Den		162	charcoal	Vinh Phuc		Bln.2957	3000±60		-
Thanh Den				Vinh Phuc		IAAA-113202	2,960±30		-
Thanh Den	P2.F4			Vinh Phuc		IAAA-113203	2,970±30		-
Man Bac	99.MB.H1.L3	80	bone	Ninh Binh	Pre Dong Son	HNK-11/2	2830±90	-16.0	-
Man Bac	MB.99.H2.L7	120-140	Sea shell	Ninh Binh	Pre Dong Son	HNK-7/1	6660±70	0.00	-
Man Bac	MB.99.H2.L7	120-140	Sea shell	Ninh Binh	Pre Dong Son	HNK-7/2	6870±70	0.00	-
Dai Trach		90	Charcoal	Bac Ninh	Dong Dau	Wk.8274	3860±60		-
Dai Trach			Organic	Bac Ninh	Dong Dau	ANU	3060±60		-
Dai Trach			Organic	Bac Ninh	Dong Dau	ANU	3890±60		-
Nga Van	05NV	93-96		Thanh Hoa	Dong Son	PLD-5118	6174±27		-
Dong Son	O5DS	184-188		Thanh Hoa	Dong Son	PLD-5117	6169±28		This study
Dong Son	05DS	128-132		Thanh Hoa	Dong Son	PLD-5116	5312±26		This study
Dong Son	09DS	123	Organic	Thanh Hoa	Dong Son	PLD-24936	5550±25		This study
Dong Son	09DS	180	Organic	Thanh Hoa	Dong Son	PLD-24937	5585±25		This study
Dong Son	09DS	305	Charcoal	Thanh Hoa	Dong Son	PLD-20928	6150±25		This study
Dong Son	09DS	515	Charcoal	Thanh Hoa	Dong Son	PLD-20929	5940±25		This study
Dong Son	09DS	600	Organic	Thanh Hoa	Dong Son	PLD-20930	6730±25		This study
Dong Son	12DSK02	261.5	Organic	Thanh Hoa	Dong Son	AA100305	3898±43		This study
Dong Son	12DSK02	401	Organic	Thanh Hoa	Dong Son	AA100306	4810±45		This study
Dong Son	12DSK02	564	Organic	Thanh Hoa	Dong Son	AA100307	7043±56		This study

(Pham and Nguyen, 2000; Nakamura, 2013:103-107; IAAA- Paleo Labo. (Japan), AA Arizona AMS Lab., PLD (Paleo Labo. (Japan), ANU (National University of Australia)

CHAPTER 5

DISCUSSION AND CONCLUSION

5.1. Holocene sea level change and its effect on socio-cultural development in Northern Vietnam

Geological researches in Northern Vietnam suggest that the study area discussed in this thesis was during the Holocene, mainly influenced by the action of the river and tides, although their role through time may have varied.

- During the early Holocene, our understanding of the main areas affected by riverine flooding, and the influence of sea level rise, is limited because sea levels were lower. Delta formation was initiated near Hanoi at about 9,000 cal. yr BP, coinciding with a deceleration of postglacial sea-level rise (Hori et al., 2004; Tanabe et al., 2006, Dinh et al. 1995). At 8,000 cal. yr BP, sea level was 5 m below current mean sea level and rising, reaching current sea level at c. 7,000 cal. yr BP (Tanabe et al., 2003b). Natural vegetation of this period consists mainly of terrestrial plants, with very few brackish and mangrove plant species (Nguyen 2008, 2013). Herbaceous plants mainly consisted of the *Acanthus*, *Acrostichum*, Poaceae, and Compositae; pollen of arboreal plants from mountainous areas of northwest Vietnam with typical temperate subtropical climates (Dinh Van Thuan et al., 1995)

- The Early–Middle Holocene is characterized by the strongest Flandrian transgression. Accordingly the entire study area was influenced by strong sea level fluctuation. Sea level reached a height 2–3m above current mean from approximately 6,000–4,000 cal. yr BP (the Holocene sea-level highstand)(Tanabe et al., 2003b). The shoreline changed across large areas, and close to the current locations of Hanoi and Ha Dong. During this time, mangroves rapidly diversified in number and composition, represented by species (?) such as *Avicennia*, *Rhizophora*, *Bruguiera*, etc., and brackish water vegetation was plentiful (Pham Van Hai et al., 2004; Dinh Van Thuan et al., 1995; Nguyen 2006, 2007). Especially from this period, *Nypa fruticans* was also detected in some samples (*Nypa fruticans* is today distributed only in Southern Vietnam) (Dinh Van Thuan et al., 1995). It can be said that the early - middle Holocene is the period of the fastest growing mangrove vegetation in Northern Vietnam, representing the early stages of formation of the coast and marshlands, with a deltaic environment prevailing. However, later stages are characterized by delta

front and delta plain wetlands. During this period, the algal assemblage was dominated by marine and brackish water species. Foraminifera are also represented by a very diverse assemblage, characterized by deltaic species (Dinh Van Thuan et al., 1996). Combined with the presence of pollen, the climate of this area can be defined as subtropical to humid tropical.

- During the Mid– Late Holocene, sea level gradually fell to that of current mean sea level over the period 4,000–0 cal. yr BP (Tanabe et al., 2003b). This period is characterized by abrupt changes to the coastline, very close to the present coastline. The proportion of mangrove species in the pollen assemblages is nearly the same as in previous periods, but with a decrease in the amount of *Nypa fructicans*. The proportion of fern spores has in turn increased more than in previous periods. This reflects a dynamic, but overall more humid environment (Do Van Tu et al., 1997). During the late Holocene, mangroves significantly reduced, and foraminifera became rare. All of this evidence indicates that marshes and tidal environments prevailed.

Maloney (1992) synthesized sea level change data from the Southeast Asian Holocene including sea level fluctuation from the Straits of Malacca. It was reported that sea levels across the region reached their peak at about 5m above mean sea level c. 4,000 yr BP then declined rapidly to 3m at c. 3,000 yr BP and 1.5m by c. 2,000 yr BP. Other studies, however, have suggested a higher sea level, of approximately 4m, at c. 6,800 yr BP, a decrease by c. 5,000 yr BP, a subsequent rise to 3.5m at c. 4,000 yr BP, another decline to 1.0m by c. 3,700 yrBP, another rise, to 2.5m, by c. 3,000 yr BP, and then a possible steady decline into the early years AD. which curve is accepted obviously has repercussions for interpretation of the human response to environmental change. If sea level change was purely eustatic it is, of course, a response to worldwide climatic change, and therefore some of the pollen diagrams from the area do contain palaeoclimatic information (Maloney 1992).

Holocene sea level changes also had a strong impact on the distribution of archaeological sites in Northern Vietnam (Ha Van Tan 1998; Nishimura and Nishino, 2003; Funabiki et al., 2012).

The Neolithic in Northern Vietnam occurred across the transition from the Pleistocene to the Holocene, with current dates from about c. 5,500-3,500BP. It directly followed the Hoabinhian period which is well known, not only in Vietnam, but throughout Southeast Asia, for its distinctive diversity of lithic tools. During the early Neolithic, known sites appear distributed across a wide range of terrains, including rock shelters at or below approximately 25m above sea level. In the late Neolithic period, sites can be found scattered across the plains and coastal areas of Hai Phong, Quang Ninh, Thanh Hoa, and Nghe An province, but especially within the floral bioregions adapted

to tropical and humid climatic patterns. The cultural achievements of the Hoabinhian and post Hoabinhian cultures established favorable prerequisites for the formation and development of subsequent Neolithic archaeological cultures.

Funabiki et al. (2012), when investigating the settlement history of the Red River Delta, concluded that after 4,000 cal. yr BP, settlements corresponding to the late Neolithic (4,500–3,500 cal. yr BP) were widespread on the west floodplain, where their elevations above the southern coastal areas made them suitable human habitat. There are only nine archaeological sites located on the edge of natural levees (but not between the present artificial dykes), and three sites date to the late Neolithic, and were excavated within marginal estuarine conditions. No sites are currently known from the eastern side of the present Song Hong River. Some sites have also been documented on beach ridges, where progradation of deltaic sediments began to form a lobate delta in a wave dominated open coastal environment. By c. 3,000 cal. yr BP, land cultivation had commenced around human settlements in the Red River Delta, which spread across the marginal swamp areas of the west floodplain, as well as the Holocene river terraces located along the north-eastern region of the delta plain. During this time, human settlements spread mainly into the marginal swamp environments. Eight of the late Metal Age archaeological sites known are located on natural levees, while 23 sites were identified within the marginal swamplands (Funabiki et al., 2012).

5.2. Vegetation and its change

Pollen analysis is a useful tool for reconstructing vegetation and land-use patterns in the past. Different floral ecosystems have their own characteristic pollen assemblages. The pollen analysis from each site, combined with archaeological and environmental data, may give a clearer picture of the cultural and environmental landscape during the Holocene in Northern Vietnam.

To reconstruct the vegetation and understand more about the ecology, the analyzed palynological assemblage was classified into five groups as follows (see Table 5): Tropical arboreal species; subtropical arboreal species; temperate arboreal species; herb; and fern spores for Neolithic period. In addition, six groups, including tropical arboreal species, subtropical arboreal species, temperate arboreal species, mangrove and black mangroves, and herb and fern spores, were delineated from Metal Age sites (see Table 11).

The results show that floral ecosystems during both chronological periods were mosaics of grassland, shrub trees and native forests, reflecting both natural and cultural influences on the environment. Within the cave sites (mostly dating to the Neolithic), fern spores occurred in higher

percentages than other plant groups, indicated humid conditions. On the other hand, at sites located on the plains, pollen of arboreal and non arboreal species was dominant.

The direct evidence of vegetation changes derived from palynological and macrofossil analyses presented here shows that Neolithic people were familiar with several cereal food crops and had begun the process of plant domestication (see Table 5 and Table 11). The identified pollen appears to have a close relationship with contemporary plant cultivars, most importantly *Poaceae* pollen, in virtually all the analysed samples, some of which have a diameter larger than 30µm and thus possibly relate to the domestic cereals (Zheng et al., 2009). This information is very valuable in its own way. Among the pollen assemblages identified, it is important to note the ubiquity of *Leguminosae* pollen, as well as *Chenopodiaceae*, *Rubiaceae*, *Compositae*, and *Malvaceae*. This type of pollen assemblage appears in most of the known archaeological sites analysed to date, particularly in younger stratigraphic layers, and thus may be related to cultivar species. This suggests that from the Neolithic onwards, the inhabitants of Northern Vietnam may have begun to cultivate crops (Zhen Li et al., 2009).

It can be said that palynology can clarify the preconditions required for the development of the more intensive cultivation and domestication evident at sites of the subsequent Hung Vuong period, corresponding to the Late Neolithic/Early Bronze Age, as well as provide a holistic interpretation of floral ecosystem transitions from the Neolithic to the Bronze Age in Northern Vietnam. However, in order to interpret which types of plants were grown by humans, and whether or not rice was domesticated, it would be necessary to analyze more samples, including macrofossils. Fragments of stone fruit pits and seeds have been recovered at Con Moong cave (Thanh Hoa province), Xom Trai and Cho cave (Hoa Binh province), including species such as *Gnetum montanum*, *Linstora cochinchinensis*, *Elaeocarpus sylvestris*, *Phyllanthus emblica* L., *Thea* sp., *Canarium* sp., *Cucumis* sp., *Lagenaria* sp., *Areca* sp., *Livistona* sp., and *Prunus* sp. All of these may have been exploited food sources during this time. Some of them are still regularly harvested by the Muong ethnic minority (Nguyen and Vu 1987; Gyong Ah Lee, pers.comm., 2007). During the Metal age (after 4,000 kyr BP), evidence for agricultural activities becomes clearer when the number of burnt rice grains (such as those found at Dong Dau, Thanh Den (Vinh Phuc province), Xuan Kieu (Ha Noi), and Lang Vac (Nghe An) increase, along with other macrobotanical species such as bamboo, cyperus and rattan imprint on pottery (*Calamoideae*), gourd ladles, and evidence for numerous styles of fabric have also been recovered from the Chau Can site (Ha Tay) and Viet Khe

site (Hai Phong). This diversification and intensification of agriculture substantially altered the landscape (Elenanor et al., 2006).

Research on the dentition of the skeletal assemblage from the Nui Nap site (Thanh Hoa), dating to *c.* 2,500 yr BP produced some interesting results (Oxenham et al., 2002). They discovered that the distinctive reddish-brown stain commonly observed on the labial aspect of the anterior teeth of the inhabitants of Nui Nap can be traced to incidental or deliberate application of betel nut compounds. The caries prophylactic effects of betel nut use are not apparent in the Nui Nap sample, however. A possible reason for this is that betel nut was not chewed, but rather betel nut residues were deliberately applied to the teeth. Human use of betel nut has been demonstrated in Northern Vietnam from at least 2,000 yr BP. This is the earliest substantiated use of *Areca catechu* in Southeast Asia to date (Oxenham et al., 2002).

Cumulatively, the results discussed above have allowed for a new and improved understanding of previously established vegetation sequences, giving a clearer picture of the cultural and environmental landscape of the prehistoric period in this area.

The vegetation profile of the Dong Son site

It is clear that the main occupation of the Dong Son site was from *c.* 3,000 yr BP to 10 yr AD, but there are carbonized particles found within cores dating back to $5,940 \pm 25$ yr BP (at 515cm depth) and $6,150 \pm 25$ yr BP (at 305cm depth). They give evidence for disturbance of the vegetation. The upper parts of all pollen diagrams produced from these cores are dominated by Poaceae pollen grains. A large increase begins at a depth of 120 cm within the 09DS, 12DSK02 and 05DS cores. This was followed by a brief return to mangrove vegetation, and then a subsequent increase in grass pollen. The latest grass dominated phase dates to the period of certain human occupation of the site. It is possible that additional excavation of this very large site would reveal earlier occupancy. Almost every sample from a depth of 100 cm to 250 cm (450cm at 12DSK02 core) contained mangrove or back mangrove pollen, excepted samples from the 07DS profile because of high location elevation. Rhizophoraceae pollen (*Rhizophora*, *Bruguiera/Ceriops*), at the depth from 2-3m, is indicative of acid sulphate soil deposition in this area (see 09DS core). This soil is typical of mangrove swamp habitats, and mangroves can live quite well, but when the land is drained rapidly, then the soils become extremely acidic. Sulphuric acid is released and the clays deflocculate, so soil structure is destroyed (Maloney 1992). Other tree pollen types, such as *Castanopsis* sp., *Quercus* sp., *Magnoliaceae*, *Meliaceae*, *Alnus* sp., are mainly a mixture of

indigenous lowland monsoon forest species, along with some pine. The amount of pine pollen is so low that it is unlikely that pine was growing anywhere near the site (see Table 11). Turning to shrubs and herbs, we have grains of Rubiaceae, Myrtaceae, Poaceae, Cyperaceae, and Asteraceae, all of which grow wild in abundance (Appendix 2, 3, 4). Also present are taxa common in freshwater environments, such as the swamp tree species *Ilex* sp., *Alnus* sp., Cyperaceae, and Poaceae. This section of the diagram overlies what seems to be an incipient acid sulphate soil which, probably erroneously, does not immediately predate the formation of the freshwater swamp.

There is also the fact that the pollen grains preserved from Dong Son are in low concentrations, perhaps due to the nature of the sediment from the cores themselves. Sediment from the Dong Son site is (from top to bottom) mostly clay, silty clay, sandy silt, coarse, laterite, and rock, characteristic of alluvial sedimentation. In Northern Vietnam, this stage began at the end of the Middle Holocene, when the shoreline resumed its migration seaward. In general, alluvial sediments are predominantly inorganic, and often contain fossil pollen.

Returning to the site, the Dong Son site is located near the Ma River, about 16km from today's coast. This area is surrounded by low limestone mountains (about 90m height), and the alluvial lowlands lies inside the arc of those mountain (Fig. 33; Photo 17, 18). It was possible that the physical transport of pollen in inorganic sediments caused by fluctuation of the Ma river lead to mechanical damage. If the origin of the pollen is within the soil covering the river catchment, then oxidation and microbial degradation is also likely to have led to further pollen deterioration. In the lower reaches of the river delta, marine influence may be felt, particularly in the erosion and reworking of the alluvial sediments themselves (Moore et al., 1991).

Climate

Pollen analysis is a poor indicator of climatic change therefore it is very difficult to extract the meaning of climatic data from the vegetation data. What can be said is that, with the decline in sea level from a post-glacial high of perhaps 3m above present levels, a large land area in Northern Vietnam, including the Thanh Hoa plain, will have come under more seasonal conditions, and that this change probably took place around 4,000-3,500 yr BP and would surely have had the greatest impact on coastal communities.

5.3. Human Activities

Agricultural Activities: The debate surrounding the onset of agriculture in the region is of current interest, but its understanding is hampered by insufficient information regarding its

palaeoenvironmental context (Maloney 1994). The diversification of the most common stone tool forms and exploited plant species, as indicated through pollen and macrofossil analysis, seems to demonstrate a close relationship between plants and people during the Neolithic in northern Vietnam, which predates demonstrable plant cultivation. The cultural achievements of the Hoabinhian and post Hoabinhian cultures established favorable prerequisites for the formation and development of subsequent Neolithic archaeological cultures. The definition of agriculture in the Neolithic is here considered in wider regard as horticulture rather than agriculture. The palynologist interested in early agriculture is concerned with identifying the pollen of possible cultivars, and weed indicators of agriculture conditions (Maloney 1994). It is still impossible to distinguish domestic plants from wild cultigens by the analysis of pollen alone. However, sites with a diverse stone tool assemblage, such as polished axes, hoes, knives, crushing, and grinding stones, as well as pointed tools made of bone, wood and stone suggest an association with agricultural practices.

It is generally accepted that Neolithic people were hunter-gatherers, but indirect evidence of stone tools i.e. polished axes and adzes, stone hoes, knives, etc. are associated with cord-marked pottery and small slate knives, believed to be used for agricultural purposes. From the Hoabinhian-Bacsonian transitional site of Con Moong cave, archaeologists have recovered a large number of stone tools, mainly made from quartz, andesite, and andesite-porphia, all of level 6 or higher on the Mohs scale of mineral hardness. Depending on the size and shape, it can be used for cutting timber, clearing grass, hunting, or digging soil. Baikan (2011) stated that: “the connection between (re)appearance of bifacial tools and the transition from nomadic hunting-gathering to settled agriculture is not incidental. Bifacial tools developed as a solution to a practical problem; they played an important role in the life of early settlers. The Neolithic axes were an essential and significant tool, used for most important daily activities, and agriculture is not suitable without axes.” When assessing previous syntheses of stone tools from the Hoabinhian to post Hoabinhian cultures such as the Bac Son, Da But, Quynh Van, and Ha Giang culture in Vietnam (see Table 13) it can be seen a huge number and diversity of tool types that have been interpreted as for activities related to initial cultivation (Ha 1998).

Around 10,000 to 8,000 yr BP fishing communities developed along the coast of Nghe An, Hai Phong, Quang Ninh and Thanh Hoa Province, as evidenced by mounds (called middens) of discarded mollusk shells 5 to 6 m high and hundreds of square meters in area, exemplified by sites such as Quynh Van, Da But, Bai Beo, and Hoa Loc sites. These middens also contained animal

bones. Stone tools in coastal areas, as well as shells in caves quite far inland, indicate early trade between regions.

Table 14: Archaeological artifacts showing technological transitions.

Stone tools Culture	Pebbles	Choppers	Polished Axes and adzes	Agriculture tool	Environment
Hoa Binh	421	3915	125	Stone hoe	Karst limestone
Bac Son	121	402	355 (partly)	Stone hoe	Karst limestone
Da But			36	Stone hoe	Coastal plain
Quynh Van	328	253	3		Coastal plain
Ha Giang			381	Stone hoe	Karst limestone
Mai Pha			97		Karst limestone

Source: Ha 1998: 166, 169, 173, 192, 204, 250, 255-6

The evidence for cultivation during this period illuminates the conditions required for more intensive cultivation and domestication apparent Phung Nguyen sites. Together with further refinement of stone tool assemblages relating to cultivation, including polished axes and knives (e.g. the Trang Kenh site, Hai Phong province and Go Hen site, Hanoi); and sickles (e.g. the Go Bong site, Phu Tho province) (Han Van Khan, 2004; Chu Van Tan, 1979). The rich and diverse pottery assemblage indicates economic stability, suggesting that settled agriculturalists inhabited the Red River region by the later Phung Nguyen period (Ha 1999).



Photo 28: Burnt rice from the Thanh Den site (2010 excavation), photo courtesy of the author

To meet agricultural needs, people began to fell trees and clear bushland to create open fields, evident in the pollen diagram by the reduced amount of arboreal pollen. Rice husks and burnt rice grains were encountered under the Dong Dau cultural layers at the Dong Dau and Thanh Den sites in Vinh Phuc province (Ha, 1999; Nguyen Xuan Hien, 1980) (see Photo 28). Archaeologists have discovered many artifacts that provide evidence of the continued development of rice cultivation, including bronze plowshares, sickle blades, and depictions of people planting or pounding rice.

According to Elenanor (2006), in Asia, the first evidence for rice cultivation comes from the region encompassing southern China, northeastern Thailand, and northern Vietnam. People appear to have first domesticated and regularly cultivated Asian rice in the Yangtze Delta around 6,400 yr B.C.E. and communities to the south, in present day Vietnam, were cultivating rice by 3,000 to 2,000 yr B.C.E. (Elenanor et al., 2006).

In a separate odontological analysis, Bower and colleagues (Bower et al., 2006) revealed interesting results indicating that the inhabitants of Nui Nap (Thanh Hoa), living during the Pre-Dong Son (Bronze Age), seem to have relied heavily on C3 plants (probably rice) with less use of marine productions, when compared to earlier inhabitants of this area, such as the Da But period site of Con Co Ngua sites (early Neolithic period). This is consistent with the expectation that agriculture was well established by the Metal Age, and suggests that rice may have begun to play a role in mid-Holocene diets in Northern Vietnam. These results will help to build hypotheses that can be further tested by isotopic analysis of new assemblages in future.

At the same time, pottery flourished making with very beautiful and harmonious motifs, as evident on fine, burnished examples of Phung Nguyen, Dong Dau and Go Mun pottery. The technique for making pottery also improved, with typological diversity, kiln temperatures, and overall ceramic numbers increasing. This had growing implications for the surrounding environment (Elenanor et al., 2006). Charcoal particles initially indicated vegetation disturbance, possibly of herbaceous vegetation types. The adoption of metal brought significant change to local lifeways, and it is a rather clear point along the prehistoric trajectory in Vietnam. The techniques and development of metallurgy and metalworking typical of the Dong Son culture marked its highest prehistoric florescence. Bronze objects from Dong Son sites are of the highest refinement artistically as well as technically, for example, bronze drums produced in a variety of sizes and ornate decorations, even smaller objects such as fishhooks and personal ornaments also show extremely high aesthetics.

Decorations on the Dong Son bronze drums also illuminate perceptions and uses of the environment during this time. Illustrations depict the sun, herds of deer, buffalo, aquatic birds, and men robed in garments decorated with feathers of aquatic birds.

During the Metal Age, as agriculture and domestication of animals took precedence over hunting and gathering, people became increasingly sedentary and the requirements of daily life began to have broader impacts on the local environment. Prehistoric change is most strongly associated with agricultural activities. Cultural landscapes associated with modification of the environment appear in conjunction with agro-ecosystems during the Holocene, when human influences are seen to override environment one (see Fig.45) (Head 2000).

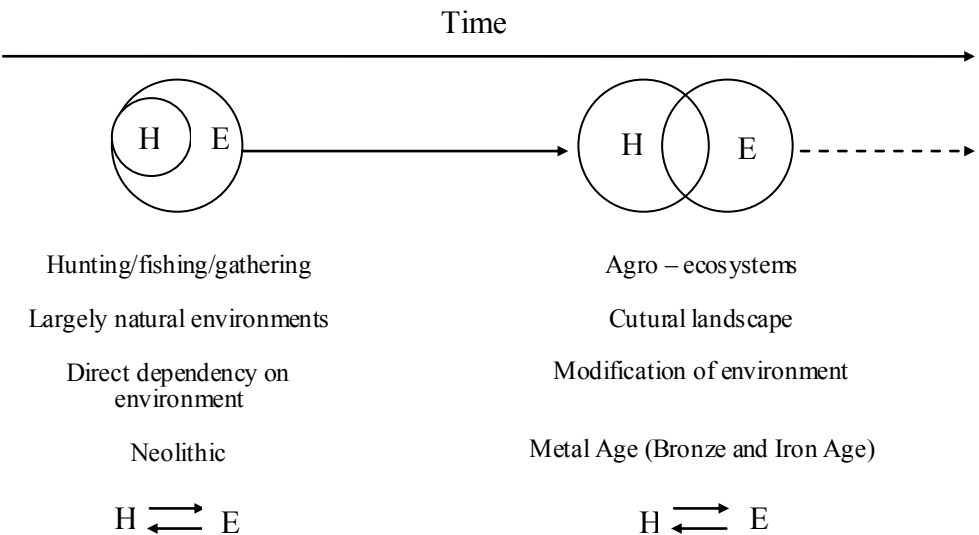


Fig. 44: The changing relationship between human (H) and its environment (E) throughout Holocene (modified after Head 2000:18)

5.4. Conclusions

Pollen analysis from archaeological sites dating to the Holocene suggests that the botanic ecosystem of this area at the time was possibly a mosaic of grasslands, shrub trees and native forests (see Tables 5 and 11). Based on this analysis, it is argued that the vegetation during the Holocene in northern Vietnam reflects both natural and cultural influences on the environment.

During the Neolithic period, pollen analysis result show comparatively low concentrations of pollen and spore overall. To reconstruct the vegetation and understand more about the ecology, results from the palynological analyses were classified into five groups (see Table 5): Tropical plants are characterized by Magnoliaceae (*Magnolia* sp.), Moraceae (*Morus* sp.), Sapindaceae (*Sapindus*

sp.) and Rubiaceae; while sub-tropical plants consist mainly of Fagaceae (*Castanopsis* sp.) and Hamamelidaceae (*Liquidambar* sp., *Hamamelis* sp.). Temperate plants include Pinaceae (*Pinus* sp.), Fagaceae (*Quercus* sp., *Castanea* sp.), Juglandaceae (*Juglans* sp.), Ulmaceae (*Ulmus* sp.), Aquifoliaceae (*Ilex* sp.) and herbs such as Compositae, Chenopodiaceae, Malvaceae, Leguminosae, Cyperaceae and Poaceae species. Fern spores is a primary species of the Pteridophyta family (*Lygodium* sp., *Polypodium* sp., *Microlepia* sp., *Stenochlaena* sp., *Cyathea* sp., *Acrostichum* sp.).

Pollen analyses from pre Dong Son archaeological sites have suggested that the flora of Northern Vietnam is a combination of herbs, shrubs and primary forest. It not much different than the Neolithic period; they are mostly tropical plants that prefer hot and humid climates (Table 11). In a number of archaeological sites, spores were dominated, especially within lower stratigraphic layers, this phenomenon demonstrates the wetter conditions of the area. Quantities of herb pollen from species such as Poaceae and Compositae increased, while percentages of woody plant pollen from species within families or genera such as Magnoliaceae and *Pinus* sp. reduced, perhaps due to the influence of man. The pollen of Poaceae occurred in high percentages, with large pollen grain size in some samples perhaps relating to paddy cultivation and agricultural activities. In addition, within the Phung Nguyen layers at the Dong Dau and Thanh Den sites (Vinh Phuc province), Xuan Kieu site (Ha Noi), and Lang Vac site (Nghe An), archaeologists have found numerous burnt rice grains. This represents the most authentic evidence for agricultural activity and the relationship between humans and vegetation profile changes.

At the Dong Son site (late Metal Age), pollen from mangrove species occurred from approximately 1 to 6m depth, mainly belonging to *Rhizophora* sp. and *Bruguiera* sp. (see Table 11), with related dates of approximately 4,810±45 yr BP to 7,043±56 yr BP (see Table 12). This indicates that at the time, higher sea levels covered the shallows. After this time, mangrove pollen gradually reduced within the core sample, corresponding to the period between c. 5,000-4,000 yr BP, disappearing between c. 4,000-3,000 yr BP. It can be concluded that the seashore had transgressed far enough to form the present coastline by this period.

In the upper section of each of the pollen diagrams (from the surface to approximately 1-2m depth, dating to c. 3,000-2,000 yr BP), the assemblage is dominated by grass pollen grains, as well as fern spores primarily consisting of *Lygodium* sp., *Polypodium* sp., *Cyathea* sp. Polypodiaceae, *Stenochlaena* sp., and *Microlepia* sp. The tree pollen types are mainly a mixture of indigenous lowland monsoon forest species, such as *Castanea* sp., *Castanopsis* sp., *Lithocarpus* sp., *Magnolia* sp.,

Michelia sp., *Quercus* sp., *Palmae*, *Myrtus* sp and some pine (*Pinus* sp.). The amount of pine pollen is so low that it is unlikely that pine was growing anywhere near the site. Non-arboreal pollen from each core section was analyzed, showing particularly apparent increases in Poaceae, whereas the gradual reduction of arboreal pollen may be due to human land clearance (see Figs. 32, 36, 37, 39, 42). The Poaceae pollen in all the pollen diagrams is comprised primarily by large grains (above 30 μm in diameter) may include *Oryza sativa* and small pollen of grass. This provides yet more evidence demonstrating that agricultural activities occurred around the Dong Son site at that time.

It is very difficult to extract meaningful palaeoclimatic data from the vegetation data. All that can be said is that, with the decline in sea levels from a post-glacial high of perhaps 3m above present sea level, a large area of land in Northern Vietnam, including the Ma River delta, will have come under more seasonal conditions, and that this change probably took place around 4,000-3,500 BP and would surely have had a profound impact on the coastal communities.

The data presented here provided a picture of environmental change and human–environment interaction throughout the Holocene in Northern Vietnam. Combining pollen analysis results and archaeological evidence, we posit a relationship between vegetation changes and the early agriculture related land clearance activities of prehistoric populations. Despite this picture, there are still significant gaps in our knowledge, and significant unresolved issues that currently prevent a more complete understanding of paleoenvironmental transitions in Northern Vietnam. The discussion and interim synthesis of the data presented in this study may serve to highlight areas of progress in this research, especially at the site of Dong Son itself, as well as highlight areas for future research.

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Appendix 1: Sediment grain size of 07DS profile

Component		Clay			Powder		Very fine sand			Fine sand				Middle sand			Big sand			Coarse sand			Coarse			Coefficient		
N	Sample sign	<0,001	0,001-	0,005-	0,01-	0,05-	0,063-	0,08-	0,09-	0,1-	0,125-	0,16-	0,2-	0,25-	0,315-	0,4-	0,5-	0,63	0,8	1,0-	1,25-	1,6-	2,00	2,5	>3,15	Md	So	Sk
			0,005	0,01	0,05	0,063	0,08	0,09	0,1	0,125	0,16	0,2	0,25	0,315	0,4	0,5	0,63	0,8	1	1,25	1,6	2	2,5	3,15				
1	B2L3-4		17.5	14.6	15.8	0.4	2.5	1.3	1	3	2.7	2.6	1.6	1.5	1.7	1.5	1.9	2.2	2.1	2.9	3.7	4.3	4	4.1	7.1	0.075	12.43	1.38
2	C3L3-4		8.2	12.1	14.8	0.7	0.7	0.6	0.6	2.2	1.7	2.4	1.6	1.2	1.3	1.1	1.2	1.4	1.3	1.8	2.7	4.6	4	14.2	19.6	0.586	14.33	0.11
3	DS07-M13	21.2	23.6	20.4	9.9	1.9	6.3	2.5	2.3	1.9	3.3	1.6	1.4	2.7	1											0.006	5.17	2.32
4	DS07-M12	21.6	25.9	17.6	10.7	2.2	3.8	1.8	1.3	1.1	1.2	2.8	5.9	2.3	1.8											0.005	4.93	1.67
5	DS07-M11	17.2	32.5	15.4	13.9	3.3	2.8	1.1	1.8	2	2.3	1.7	2.3	1.9	1.8											0.005	4.28	1.83
6	DS07-M10	21.2	28.9	15.9	11.3	2.7	3.8	1.2	1	1.2	3.9	5.1	2.1	1.7												0.005	4.68	1.56
7	DS07-M9	17	36.1	12.9	17.2	1.8	2.7	2.2	1.1	1.2	2.8	2.5	1.5	1												0.004	3.81	1.72
8	DS07-M8	23	28.7	20.3	13.3	1.5	3.7	1.5	1.8	1.2	2	0.9	1.4	0.7												0.005	3.14	0.66
9	DS07-M7	24.1	19.9	27.8	11.3	2.1	2.5	1.3	1.3	1.9	2	1.6	2.4	1.8												0.005	3.06	0.53
10	DS07-M6	18.2	28.6	23.4	15.8	0.8	3.2	2.2	1.1	1.7	2.2	0.8	1.1	0.9												0.005	2.53	0.74
11	DS07-M5	14	34.8	19.1	11.2	1.1	4	1.1	1.3	1.4	2.2	2.8	1.5	2.1	2.2	1.2										0.005	2.84	1.19
12	DS07-M4	17.3	28.9	27.3	11.6	0.9	5.8	1.2	1.8	1.8	1	0.6	0.8	1												0.005	2.3	0.75
13	DS07-M3	18.7	23.3	23.2	13.8	1.2	5.8	1.9	2.1	1.8	3	1.1	1.1	1	1.3	0.7										0.006	2.86	1.09
14	DS07-M2	12.7	30.4	18.2	11.9	3.8	7.1	2.1	3.8	2.8	3.2	1.9	1.3	0.8												0.006	4.73	3
15	DS07-M1	13.8	29.4	25.8	13.9	1.1	3.7	1.8	1.4	2.1	3.2	2	1.8													0.006	2.17	0.9

Appendice 2: Current plant at Dong Son Village

Arboreal	Shrub	Herb	Fern
<i>Eucalyptus camaldulensis</i> Dehnhart	<i>Streblus ilicifolia</i> (Kurz.) Corn.	<i>Symbopogon</i> sp.	Polypodiaceae
<i>Artocarpus heterophylla</i> Lamk.	<i>Zizyphus</i> sp.	<i>Cauropus androgynus</i> L.Mrr	
<i>Khaya senegalensis</i>	<i>Averrhoa caranbola</i> L	<i>Ocimum basilicum</i> L..	
<i>Terminalia catappa</i> L.	<i>Carica papaya</i> L.	<i>Alocasia</i> sp.	
<i>Alstonia scholaris</i> (L.) R. Br.	<i>Dimocarpus fumatus</i> (Bl.) Leenh. Subsp. Indochinesis Leenh	<i>Colocasia</i> sp.	
<i>Melia azedarach</i> L.	<i>Areca betel</i>	<i>Piper saigonensis</i> C.DC..	
<i>Markhamia stipulata</i> (Wall.) Seem.ex Schum.	<i>Cocos nucifera</i>	<i>Solanum thurpii</i> H. Wringht.	
<i>Mangifera cochinchinensis</i> Engl.	<i>Psidium guajava</i>	<i>Datura metel</i>	
<i>Mangifera reba</i> Pierre.	<i>Annona squamosa</i>	<i>Biden pilosa</i> L.	
<i>Acacia magium</i> Willd.	<i>Pandanus</i> sp.	<i>Cassia</i> sp.	
<i>Delonix regia</i> (Hook.) Raf.	<i>Aralia armata</i> Seem	<i>Plantago major</i> L	
<i>Bombax ceiba</i> L.	<i>Rosa</i> sp.	<i>Polygonum</i> sp.	
<i>Dracuntomelon duperreanum</i> Pierre.	<i>Citrus grandis</i> L.,	<i>Celosia argentea</i> L.	
<i>Michelia</i> sp.	<i>Citrus aurantifolia</i> (Chritm.) Sw.	<i>Calamus</i> sp.	
<i>Pinus</i> sp.	<i>Musa</i> sp.	<i>Pacderia lanuginosa</i> Wall.	
<i>Aphananthe aspera</i> (Thunb.) Pl.	<i>Ficus drupacea</i> Thumb.	<i>Momordica</i> sp.	
	<i>Lagerstroemia</i> sp.	<i>Operculina turpethum</i> (L.) S.Manso	
	<i>Ficus fulva</i> Reinw. ex Bl.	<i>Pueraria montana</i>	
	<i>Urena lobata</i> L..	<i>Lablab purpureus</i>	
	<i>Ricinus communis</i> L.	<i>Piper</i> sp.	
	<i>Plumeria obtusa</i> L..	<i>Ipomoea congesta</i> R. Br.	
	<i>Pluchea</i> sp.	<i>Passiflora foetida</i> L.	
	<i>Morus</i> sp.	<i>Dioscorea</i> sp.	
		<i>Bambusa</i> sp.	

Appendice 3: Current plant on Limestone mountain of Dong Son village

Arboreal	Shrub	Non-arboreal	Fern
<i>Eucalyptus camaldulensis</i> Dehnhart	<i>Pandanus</i> sp.	<i>Melastoma sanguineum</i> Sims..	Polypodiaceae
<i>Acacia magium</i> Willd	<i>Ficus drupacea</i> Thumb.	<i>Achyranthes aspera</i> L.	
<i>Markhamia stipulata</i> (Wall.) Seem.ex Schum.	<i>Bambusa</i> sp.	<i>Imperata cylindrical</i>	
		<i>Clerodendrum paniculatum</i> L.	
		<i>Solanum thurpii</i> H. Wringht.	
		<i>Convolvulus</i> sp.	

Appendice 4: Current plant on the Ma river bank and ponds

Arboreal	Shrub	Non arboreal	Fern	Aquatic
<i>Melia azedarach</i> L.	<i>Annona squamosa</i>	<i>Manihot esculenta</i>	Polypodiaceae	<i>Nelumbo nucifera</i> Gaertn.
<i>Artocarpus heterophylla</i> Lamk.	<i>Areca betel</i>	<i>Carica papaya</i> L.		<i>N. pubescens</i> Willd. L.
<i>Terminalia catappa</i> L.	<i>Cocos nucifera</i>	<i>Musa</i> sp.		<i>Pistia stratiotes</i>
<i>Eucalyptus camaldulensis</i> Dehnhart	<i>Pandanus</i> sp.	<i>Cyperus</i> sp.		<i>Eichhornia crassipes</i> Solms
<i>Dracuntomelon duperreanum</i> Pierre.	<i>Ficus drupacea</i> Thumb.	<i>Celosia argentea</i> L		<i>Limnophila aromatica</i>
		<i>Canna edulis</i>		<i>Ipomoea aquatica</i> Forssk.
		<i>Imperata cylindrical</i>		<i>Polygonum</i> sp.
		<i>Biden pilosa</i> L.		<i>Cyperus</i> sp.
		<i>Cucurbita</i> sp.		
		<i>Ipomoea congesta</i> R. Br.		
		<i>Paederia tomentosa</i> Lour		
		<i>Dioscorea</i> sp.		
		<i>Bambusa</i> sp.		